EXHIBIT H

Report on Proposed Congressional Redistricting Plan from the Pennsylvania House Republican Caucus

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1 Introduction and Qualifications

I have been asked by counsel to review the Pennsylvania House of Representatives Republican Caucus' proposed congressional redistricting plan (hereafter, "HB2146 plan") and compare it to a set of simulated redistricting plans across a number of factors commonly considered in the redistricting process and in redistricting litigation. To do this, I implement a publicly available and peer-reviewed redistricting simulation algorithm to generate 50,000 simulated district maps, each containing 17 congressional districts. The redistricting algorithm generates a representative sample of districts by following neutral redistricting criteria without regard to partisan data. In this way, the simulated districts establish a comparison set of plans that use purely non-partisan redistricting inputs. I then compare the simulated plans against the proposed plan using a number of commonly used redistricting criteria to assess whether the proposed plan is consistent with what one would expect to see in a redistricting plan composed without reference to any racial or partisan considerations.[1] Across all measures, the proposed plan is well within the distribution of simulated plans and is unbiased, with a slight lean towards favoring Democratic candidates.

I am an associate professor of political science at Brigham Young University and faculty fellow at the Center for the Study of Elections and Democracy in Provo, Utah. I received my PhD in political science from Princeton University in 2014 with emphases in American politics and quantitative methods/statistical analyses. My dissertation was awarded the 2014 Carl Albert Award for best dissertation in the area of American Politics by the American Political Science Association.

I teach a number of undergraduate courses in American politics and quantitative research methods.[2] These include classes about political representation, Congressional elections, statistical methods, and research design.

I have worked as an expert witness in a number of cases in which I have been asked

[1] In a later section I consider the impact of considering only the simulations that meet certain thresholds with regards to the racial composition of some districts.

[2] The political science department at Brigham Young University does not offer any graduate degrees.

to analyze and evaluate various political and elections-related data and statistical methods. Cases in which I have testified at trial or by deposition are listed in my CV, which is attached to the end of this report. I have previously provided expert reports in a number of cases related to voting, redistricting, and election-related issues: *Nancy Carola Jacobson, et al., Plaintiffs, vs. Laurel M. Lee, et al., Defendants. Case No. 4:18-cv-00262 MW-CAS (U.S. District Court for the Northern District of Florida); Common Cause, et al., Plaintiffs, vs. Lewis, et al., Defendants. Case No. 18-CVS-14001 (Wake County, North Carolina); Kelvin Jones, et al., Plaintiffs, v. Ron DeSantis, et al., Defendants, Consolidated Case No. 4:19-cv-300 (U.S. District Court for the Northern District of Florida); Community Success Initiative, et al., Plaintiffs, v. Timothy K. Moore, et al., Defendants, Case No. 19-cv-15941 (Wake County, North Carolina); Richard Rose et al., Plaintiffs, v. Brad Raffensperger, Defendant, Civil Action No. 1:20-cv-02921-SDG (U.S. District Court for the Northern District of Georgia); Georgia Coalition for the People's Agenda, Inc., et. al., Plaintiffs, v. Brad Raffensberger, Defendant. Civil Action No. 1:18-cv-04727-ELR (U.S. District Court for the Northern District of Georgia); Alabama, et al., Plaintiffs, v. United States Department of Commerce; Gina Raimondo, et al., Defendants. Case No. CASE NO. 3:21-cv-00211-RAH-ECM-KCN (U.S. District Court for the Middle District of Alabama Eastern Division); League of Women Voters of Ohio, et al., Relators, v. Ohio Redistricting Commission, et al., Respondents. Case No. 2021-1193 (Supreme Court of Ohio); Harper, et al., Plaintiffs, v. Hall et al., Defendants. Case No. 21-CVS-015426 (Wake County North Carolina).* I have also recently testified before the Pennsylvania Legislative Reapportionment Commission regarding the LRC's proposed map for the Pennsylvania House of Representatives.

In my position as a professor of political science, I have conducted research on a variety of election- and voting-related topics in American politics and public opinion. Much of my research uses advanced statistical methods for the analysis of quantitative data. I have worked on a number of research projects that use "big data" that include millions of observations, including a number of state voter files, campaign contribution lists, and data

from the US Census. I have also used geographic information systems and other mapping techniques in my work with political data.

Much of this research has been published in peer-reviewed journals. I have published nearly 20 peer-reviewed articles, including in our discipline's flagship journal, *The American Political Science Review* as well as the inter-disciplinary journal, *Science Advances*. My CV, which details my complete publication record, is attached to this report as Appendix A.

The analysis and opinions I provide in this report are consistent with my education, training in statistical analysis, and knowledge of the relevant academic literature. These skills are well-suited for this type of analysis in political science and quantitative analysis more generally. My conclusions stated herein are based upon my review of the information available to me at this time. I reserve the right to alter, amend, or supplement these conclusions based upon further study or based upon the availability of additional information. The opinions in this report are my own, and do not represent the view of Brigham Young University.

2 Summary of Conclusions

Based on the evidence and analysis presented below, my opinions regarding the HB2146 plan for congressional districts in Pennsylvania can be summarized as follows:

- The contemporary political geography of Pennsylvania is such that Democratic majorities are geographically clustered in the largest cities of the state while Republican voters dominate the suburban and rural portions of the state.

- This geographic clustering in cities puts the Democratic Party at a natural disadvantage when single-member districts are drawn. Specifically, districts drawn to be contiguous, compact, and contain minimal county and municipal splits will naturally create several districts in the Philadelphia and Pittsburgh areas that contain substantial Democratic majorities with many "wasted votes."

- Based on a comparison between the HB2146 plan, and a set of 50,000 simulated maps, the HB2146 plan is a fair plan with no evidence of partisan gerrymandering across a number of different measures used to assess the fairness of a map.

- Based on an index of statewide elections from 2012-2020, the HB2146 plan generates nine Democratic-leaning districts and eight Republican-leaning districts.

- Based on the same index of statewide elections from 2012-2020, six of the districts in the HB2146 plan will likely be competitive with candidates from both parties having a realistic possibility of winning the seats. Five of these competitive districts are *extremely* competitive, with a partisan index within two percentage points of an even 50/50 split.

- Compared to a second set of simulations that explicitly consider the creation of minority opportunity districts, the HB2146 plan is similarly unbiased. The race-conscious simulations reduce the variation in Democratic-leaning districts substantially, making nine Democratic-leaning districts the overwhelmingly most likely outcome in the simulations.

- Based on these commonly-used measures of redistricting fairness, the HB2146 plan is unbiased, and when compared to the simulations on these same metrics is balanced between occasionally having a slight Republican benefit and occasionally providing a slight benefit to Democratic voters.

3 Political Geography of Pennsylvania

Scholarship in political science has noted that the spatial distribution of voters throughout a state can have an impact on the partisan outcomes of elections when a state is, by necessity, divided into a number of legislative districts. This is largely the case because Democratic-leaning voters tend to cluster in dense, urban areas while Republican-leaning voters tend to be more evenly distributed across the remainder of the state.[3] One prominent study of the topic (Chen and Rodden, 2013) finds that "Democrats are highly clustered in dense central city areas, while Republicans are scattered more evenly through the suburban, exurban, and rural periphery...Precincts in which Democrats typically form majorities tend to be more homogenous and extreme than Republican-leaning precincts. When these Democratic precincts are combined with neighboring precincts to form legislative districts, the nearest neighbors of extremely Democratic precincts are more likely to be similarly extreme than is true for Republican precincts. As a result, when districting plans are completed, Democrats tend to be inefficiently packed into homogenous districts" (pg. 241).[4]

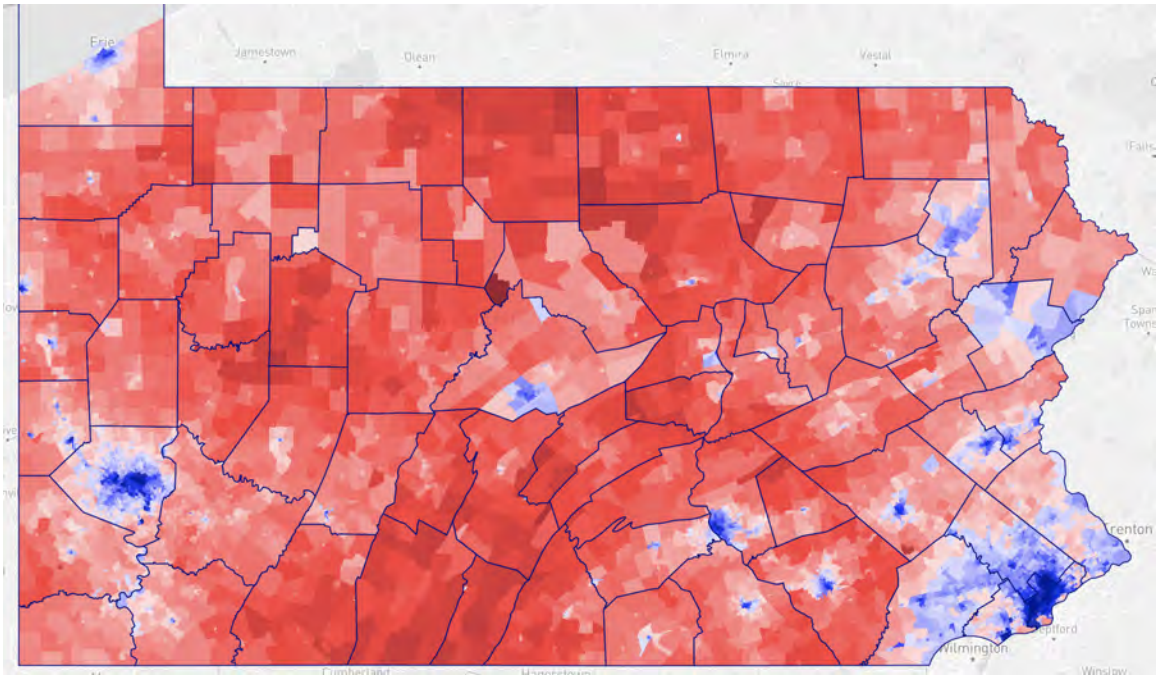
The map below confirms that this is the case in Pennsylvania. There are extremely large Democratic majorities shown in dark blue in and around Philadelphia and Pittsburgh. The remainder of the state contains smaller cities that are Democratic-leaning and large swaths of the state that are solidly Republican.

The upshot of this pattern is that a political party stands at a disadvantage when its voters are not "efficiently" distributed across the state. To understand what I mean by efficient, imagine two different scenarios. First, imagine a party with a slim majority of

[3]See for example Stephanopoulos, N. O. and McGhee, E. M., Partisan Gerrymandering and the Efficiency Gap, *The University of Chicago Law Review* 82: 831-900, (2015); Chen, J. and Rodden, J., Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures, *Quarterly Journal of Political Science* 8: 239-269, (2013); Nall, C., The Political Consequences of Spatial Policies: How Interstate Highways Facilitated Geographic Polarization, *Journal of Politics*, 77(2): 394-406, (2015); Gimple, J. and Hui, I., . Seeking politically compatible neighbors? The role of neighborhood partisan composition in residential sorting, *Political Geography* 48: 130-142 (2015); Bishop, B., *The Big Sort: Why the Clustering of Like-Minded America is Tearing Us Apart*, Houghton Mifflin Press (2008); and Jacobson, G. C., and Carson, J. L., *The Politics of Congressional Elections*, 9th ed. Lanham, MD: Rowman and Littlefield (2016).

[4]Chen, J. and Rodden, J., Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures, *Quarterly Journal of Political Science* 8: 239-269, (2013)

Figure 1: **Distribution of People and Partisan Preferences in Pennsylvania**



Note: Distribution of Partisan Preferences in Pennsylvania based on the average of statewide partisan elections. Blue = Democratic, Red = Republican

voters statewide in which every precinct's vote share perfectly reflected the overall state. In other words, the party has a slight majority in every precinct that adds up to a slight majority statewide. In this case, this party's voters are extremely efficiently distributed in such a way that the party will win every single district despite only a slim majority statewide. Now imagine a different arrangement: a party that still holds a slim majority statewide, but whose voters are heavily concentrated in a few areas and sparsely populated throughout the rest of the state. In this case, despite holding a majority of votes statewide, the party will only win a few seats where their voters are heavily concentrated. The political geography of Pennsylvania closely resembles this second scenario.

The geographic concentration of a party's voters tends to harm that party when single-member districts are drawn by creating districts that favor that party by very large margins, thus "wasting" many votes by running up large majorities far beyond 50%+1.[5]

[5]McGhee, E. (2017). Measuring Efficiency in Redistricting. Election Law Journal: Rules, Politics, and Policy, 16(4), 417–442. doi:10.1089/elj.2017.0453

This occurs in Pennsylvania at the scale of congressional districts in the two largest cities of the state - Pittsburgh and Philadelphia. The overwhelming margins for the Democratic Party in these cities are what drives "wasted votes," which in turn translate to fewer seats than the statewide proportion of votes would suggest.[6]

For example, Philadelphia is large enough to constitute roughly 2.1 congressional districts. Thus, a plan that attempts to avoid splitting counties will draw two districts entirely within the city of Philadelphia.[7] In the HB2146 plan Districts 2 and 3 are completely contained in Philadelphia. In the 2020 presidential election, the city of Philadelphia supported the Democratic candidate, Joe Biden, by an 81.4% to 17.9% margin. As a result, the two congressional districts that will be contained within the city, whatever their configuration, will be overwhelmingly Democratic and contain hundreds of thousands of wasted votes that could be used more efficiently if they were geographically distributed more evenly across the state.

The story is very similar in Pittsburgh and Allegheny County as well. Pittsburgh is not large enough to contain a single congressional district. However, its population is roughly 40% of the size required for a congressional district in 2020. Allegheny County's population is larger than a congressional district (its 2020 population was roughly equal to 1.6 congressional districts), and thus a plan that draws district boundaries that are geographically compact and avoid splitting counties and cities will contain a congressional district within Allegheny County that also contains the city of Pittsburgh. In the HB2146 plan District 15 contains the city of Pittsburgh and is entirely contained in Allegheny County. Both Pittsburgh and Allegheny County are very Democratic leaning. In the 2020 presidential election, the city supported Joe Biden by a 78% to 20.9% margin and Allegheny County supported Biden by a 59.7% to 39.2% margin. As a result, whichever congressional district Pittsburgh

[6]The term "wasted votes" in political science is not to imply that a person's vote is not important or counted, but rather that the vote is not helpful in gaining an additional seat for their preferred party if it is an additional vote in favor of a candidate that has already won a majority of the votes in their district. Technically, all votes beyond 50%+1 are "wasted". However, parties are interested in winning by majorities larger than 50%+1, but not by margins beyond the point at which their candidate is quite certain to win.

[7]Philadelphia city and county are coterminous.

is drawn into will be extremely Democratic as a result of the strong support for Democratic candidates in Pittsburgh and its immediate suburbs within Allegheny County.

Taken together, this suggests that any plan that follows the non-partisan criteria of drawing maps that are geographically compact and avoid splitting counties and cities will begin with three districts (2 in Philadelphia and 1 in Allegheny County centered in Pittsburgh) that are extremely Democratic leaning with an abundance of wasted votes. The spillover effect of this natural packing of Democratic voters is that the remaining 14 congressional districts will be more favorable to Republican voters than if the Democratic voters in these two large cities were more evenly distributed across the state.

The inefficient distribution of voters in Pennsylvania would not be a problem for Democrats if district boundaries were able to amble about the state and divide counties and municipalities to create districts that had less overwhelming Democratic support. Rodden (2019) notes this by saying: "Democrats would need a redistricting process that intentionally carved up large cities like pizza slices or spokes of a wheel, so as to combine some very Democratic urban neighborhoods with some Republican exurbs in an effort to spread Democrats more efficiently across districts" (pg. 155).[8] However, the provisions governing redistricting in Pennsylvania run counter to either of these strategies. The Pennsylvania Supreme Court's decision in *League of Women Voters of Pa. v. Commonwealth* establishes that congressional redistricting plans must adhere to traditional redistricting rules that require districts to be geographically compact and to avoid county and municipal divisions. It thus prohibits the type of meandering districts that Rodden describes above. In the end, this means that Republicans begin the redistricting process with a natural geographic advantage due to the constraints of where and how districts can be lawfully drawn combined with the particular spatial distribution of their voters.

[8]Rodden, Jonathan A. Why cities lose: The deep roots of the urban-rural political divide. Hachette UK, 2019.

4 Methods

To gauge the degree to which the HB2146 plan is a partisan gerrymander, I conduct simulated districting analyses to allow me to produce a large number of districting plans that follow traditional redistricting criteria using small geographic units as building blocks for hypothetical legislative districts. This simulation process ignores all partisan and racial considerations when drawing districts. Instead, the computer simulations are programmed to create districting plans that follow traditional districting goals without paying attention to partisanship, race, the location of incumbent legislators, or other political factors. This set of simulated districts is helpful because it provides a set of maps to which we can compare the HB2146 map that also accounts for the geographic distribution of voters. Because voters are not distributed evenly across the state (as discussed in the previous section), we cannot evaluate the fairness of a proposed plan without an apples-to-apples comparison. In other words if a plan is not evaluated against a comparison set of maps that also use the same political geography of the state, then potential issues or red flags in the map may not at all be due to partisan gerrymandering, but rather the geographic distribution of voters in the state. By comparing a proposed map to a set of alternative maps that are drawn using only non-partisan districting criteria that *also* consider the same geographic distribution of voters, we can identify if oddities or patterns in the proposed plan are due to the political geography of the state because the simulated maps are drawn *using the same political geography*. In other words, by comparing the HB2146 map to the simulated districts, we are comparing the proposal to a set of alternative maps that we know to be unbiased that holds constant the political geography of the state. If the HB2146 map produces a similar outcome as the alternative set of maps, we may reasonably conclude that the HB2146 plan is unbiased. Alternatively, if the HB2146 plan significantly diverges from the set of simulated maps, it suggests that some other criteria that were not used in drawing the comparison set of maps may have guided the decisions made in drawing the proposed map.

The process of simulating districting plans has been recognized and used in a variety

of redistricting litigation, including in Pennsylvania.[9] While different people employ slightly different methods, the overall process is much the same. For my simulations, I use a program developed by Fifield et al. (2020).[10]

A significant advantage of the simulation-based approach is the ability to provide a representative sample of possible districting plans that accounts for the unique political geography of a state, such as the spatial distribution of voters or the location and number of administrative boundaries, such a counties. Simulation methods can also to a degree incorporate each state's unique redistricting rules. The simulation-based approach therefore permits us to compare a particular plan to a large number of representative districting plans in Pennsylvania. In the simulations I run, I instruct the model to generate plans that adhere to the redistricting criteria discussed in the *League of Women Voters* case: equal population, compactness, and minimzing political subdivision splits.

A major factor in the validity of the simulated maps is whether or not they constitute a representative sample of the trillions of possible maps that could be drawn.[11] If the sample produced by the simulations is not representative, then we may be comparing the proposed map to a biased selection of alternative maps, which renders the value of the comparison much less useful.

A specific benefit of the particular algorithm I use here is that the authors show math-

[9]See League of Women Voters of Ohio v. Ohio Redistricting Commission (2021); Harper v. Hall (2021); Common Cause v. Lewis (2019); Harper v. Lewis (2019); League of Women Voters of Pennsylvania v. Commonwealth of Pennsylvania (2018); City of Greensboro v. Guilford County Board of Elections (2017); January 6, 2022 testimony for PA LRC from Kosuke Imai and Michael Barber.

[10]Fifield, Benjamin, , Michael Higgins, Kosuke Imai, and Alexander Tarr. "Automated redistricting simulation using Markov chain Monte Carlo." Journal of Computational and Graphical Statistics 29, no. 4 (2020): 715-728.

Fifield, Benjamin, Kosuke Imai, Jun Kawahara, and Christopher T Kenny. 2020. "The essential role of empirical validation in legislative redistricting simulation." Statistics and Public Policy 7 (1): 52–68.

Kenny, Christopher T., Cory McCartan, Benjamin Fifield, and Kosuke Imai. 2020. redist: Computational Algorithms for Redistricting Simulation. https://CRAN.R-project.org/package= redist.

McCartan, Cory, and Kosuke Imai. 2020. "Sequential Monte Carlo for sampling balanced and compact redistricting plans." arXiv preprint arXiv:2008.06131.

[11]Tam Cho, Wendy K., and Yan Y. Liu. "Toward a talismanic redistricting tool: A computational method for identifying extreme redistricting plans." Election Law Journal 15, no. 4 (2016): 351-366. Cho, Wendy K. Tam, and Bruce E. Cain. "Human-centered redistricting automation in the age of AI." Science 369, no. 6508 (2020): 1179-1181. McCartan, Cory, and Kosuke Imai. "Sequential Monte Carlo for sampling balanced and compact redistricting plans." arXiv preprint arXiv:2008.06131 (2020).

ematically and in a small-scale validation study that their method produces a representative sample of maps. With regards to this issue, the authors state:

> Yet, until recently, surprisingly few simulation algorithms have existed in the published scholarship. In fact, most of these existing studies use essentially the same Monte Carlo simulation algorithm where a geographical unit is randomly selected as a "seed" for each district and then neighboring units are added to contiguously grow this district until it reaches the pre-specified population threshold (e.g., Cirincione, Darling, and O'Rourke 2000; Chen and Rodden 2013). Unfortunately, no theoretical justification is given for these simulation algorithms, and hence they are unlikely to yield a representative sample of redistricting plans for a target population....Unlike the aforementioned standard simulation algorithms, the proposed algorithms are designed to yield a representative sample of redistricting plans under contiguity and equal population constraints.[12]

Specifically, the model is constrained to conduct 50,000 simulations in which each simulation generates 17 districts that are of roughly equal population (<0.5% deviation above or below the target population of 764,865). While congressional districts are constrained to contain a truly equal population, it is not possible to place such a strict constraint on the model. Because of this, I relax the constraint to allow for a 0.5% deviation, or a roughly 3,800 person deviation. This is common in redistricting simulations of congressional districts, including in litigation presented to, and relied upon by the Pennsylvania Supreme Court in the 2018 *League of Women Voters* case. The process for zeroing out population on any given simulation map would have minimal to no impact on the partisan outcomes.[13]

[12]Cirincione, C., Darling, T. A., and O'Rourke, T. G. (2000), "Assessing South Carolina's 1990s Congressional Districting," Political Geography, 19, 189–211. DOI: 10.1016/S0962-6298(99)00047-5. Chen, J., and Rodden, J. (2013), "Unintentional Gerrymandering: Political Geography and Electoral Bias in Legislatures," Quarterly Journal of Political Science, 8, 239–269. DOI: 10.1561/100.00012033.

[13]See for example: Expert report of Dr. Wesley Pegden in League of Women Voters of Pennsylvania case, whose simulations use a 2% population constraint. Expert report of Dr. Jonathan Mattingly in Harper v. Hall in North Carolina, whose congressional simulations use a 1% population constraint and states, "We have verified in previous work in related settings that the small changes needed to make the districting plan

The algorithm generates 17 congressional districts with each run by assembling small geographic units — electoral precincts — into larger groups until a group of precincts is large enough to constitute a new legislative district. It then repeats this process 50,000 times, generating a different set of 17 districts with each run of the model. In each of the 50,000 iterations, the model is instructed to generate geographically compact districts that do not divide cities, boroughs, townships, and other municipal corporations. No city in Pennsylvania is larger than a congressional district aside from Philadelphia. As a result, there are no split precincts or municipalities (aside from the necessity of dividing Philadelphia into multiple districts due to its population) in the simulated districts. I constrain the model to not split municipalities because of the constitutional instructions in Article II, Section 16 that no city, incorporated town, borough, township or ward shall be divided unless "absolutely necessary". Although Article II Section 16 does not on its face apply to congressional redistricting, the *League of Women Voters* case held that an "essential part" of an inquiry into whether a congressional plan is constitution under the Free and Equal Elections Clause is if the districts created under the plan are: "composed of compact and contiguous territory; as nearly equal in population as practicable; and which do not divide any county, city, incorporated town, borough, township, or ward, except where necessary to ensure equality of population" (645 Pa. 1, 123, 2018). Later, the court described this principle as the "minimization of the division of political subdivisions" (Id). Thus, if it is possible to generate districts that do not split municipalities and stay within the 0.5% population constraint, it is therefore not "absolutely necessary" to split municipalities aside from Philadelphia when constructing simulated districts. The process for zeroing out population on any given simulation map would, of course, require the division of some municipal corporations, but not many. The model is also instructed to draw districts that cross county boundaries as few times as

have perfectly balanced populations do not change the results." See also expert report of Daniel Magleby in Harper v. Hall in North Carolina. Also, expert report of Kouske Imai in League of Women Voters of Ohio v. Ohio Redistricting Commission, who uses a 0.5% population deviation and states, "Although this deviation is greater than the population deviation used in the enacted plan, it only accounts for less than 4,000 people and hence has no impact on the conclusions of my analysis."

possible. County populations do not always add up to round units of districts, and thus some county boundaries will be need to be traversed. The model is further instructed that when a county boundary needs to be crossed, it should avoid splitting the county more times than necessary.

Once the simulated district plans are complete, only then do I compute the partisan composition of each district in each plan. For the partisan composition of each district I rely on the election results from statewide elections disaggregated to the level of the election precinct. I then reassemble these election results for each of the simulated districts in each of the 50,000 simulations to compute the proportion of votes across all statewide elections conducted between 2012 and 2020 that were won by the Democratic and Republican candidates in those districts.[14] In other words, the partisan index is the average vote share for Democratic candidates in each district for the statewide elections considered between 2012-2020. I choose the period 2012-2020 because it represents an entire decade of elections between decennial censuses when redistricting traditionally occurs. Averages of multiple elections have the benefit of "washing out" the impact of any particular election, since individual elections can vary due to particular idiosyncratic candidate features. Furthermore, particular years can vary due to national electoral waves (i.e. 2018 was an especially good year for Democrats while 2016 was an especially good year for Republicans nationwide). Later in the report I also display the results using a variety of alternative election indices.

[14]The particular races are 2020: President, Auditor, Attorney General, Treasurer; 2018: Governor, US Senate; 2016: President, US Senate, Auditor, Attorney General, Treasurer; 2014. I do not include statewide judicial elections in the index. It is uncommon in political science to use judicial elections to measure voters' partisan preferences as research suggests voters treat judicial elections very differently, even when judges run under party labels, than they do partisan elections to legislative and executive positions. Other commonly used measures indices such as Dave's Redistricting and PlanScore.com also omit judicial elections from their partisan indices.

5 Results

5.1 Population, Boundary Splits, and Compactness

Table 1 below compares the HB2146 plan to the distribution of simulations for boundary splits, and compactness. The HB2146 plan splits 15 counties, which is within the range of county splits in the simulations. The HB2146 plan divides only 16 municipalities, one of which would be Philadelphia, which is required to be divided because the city's population is larger than a single congressional district. Furthermore, the requirement that the proposal contain exact population equality will require the division of some municipalities since the combination of cities into districts will not necessarily lead to the exact population needed for a congressional district. Finally, the HB2146 plan has only nine precinct splits. On the whole, the plan performs exceptionally well at having few county, municipal, and precinct splits. With regards to district compactness, the HB2146 plan's average district compactness score closely aligns with the results of the simulations. District-by-district measures of compactness as well as a list of specific counties and municipalities that are split are contained in the appendix of this report.

Table 1: HB2146 plan and 50,000 Simulations: Subdivision Splits, and Compactness

	HB2146 plan	Simulations Median	Simulations Range
Boundary Splits			
Counties Split:	15	12	[7, 15]
Municipalities Split:	16	1	[1, 1]
Precincts Split:	9	0	[0, 0]
Compactness			
Average Polsby-Popper:	0.32	0.28	[0.22, 0.35]

Note: As described above, the simulations are constrained to not divide municipalities, aside from Philadelphia, which is too large to be contained within one district. However, exact population equality requires some municipalities be split in the proposed plan.

5.2 Partisan Lean of Districts

Before comparing the proposal to the simulations, I first present the results of the partisan index for each district in the HB2146 plan. Figure 2 shows this for the 17 districts in the plan. Districts are ordered from least Democratic at the bottom to most Democratic at the top. Districts with a partisan index less than 0.50 are Republican leaning and districts with a partisan index greater than 0.50 are Democratic leaning. A vertical dashed line is placed at 0.50 for reference. In the plan there are eight Republican-leaning districts with an index less than 0.50 (on the left side of the dashed line at .50) and nine Democratic-leaning districts with an index greater than 0.50 (on the right side of the dashed line at .50). The grey horizontal lines around each point show the range of election outcomes for all of the statewide elections used to generate the index. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all of the statewide races in that district are shown as red squares while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all of the statewide races in that district are shown as blue triangles. Districts where both parties have won a majority of the two-party vote share in these statewide races in the district are displayed as green circles. Looking at the range across the index, there are six districts colored red (reliably Republican), five blue districts (reliable Democratic), and six green districts (competitive) in the plan. Using an alternative definition of competitiveness based on the closeness of the index to 0.50, there are five districts with an index between 0.48 and 0.52. A range of two percentage points is a commonly used measure of competitiveness in congressional elections.

A few key points come out of this figure. First, we see the result of the natural clustering of Democratic voters in Philadelphia and Pittsburgh. Districts 3 and 2 are the most Democratic leaning and are entirely contained within Philadelphia in the HB2146 plan. District 15 is the third most Democratic leaning district and contains the entirety of Pittsburgh and some of its surrounding suburbs in Allegheny County. These districts are

overwhelmingly Democratic leaning. In fact, they are much more Democratic than the degree to which the most Republican-leaning districts lean towards Republicans. For example, the most Democratic district (District 3) has a partisan index of 0.92 while the most Republican district (District 13) has a partisan index of 0.35 (0.35 is much closer to .50 than 0.92 is to 0.50). This illustrates the idea that geographic clustering of voters when divided into single member districts that are compact and avoid dividing counties and cities generally lead to more wasted votes for Democrats than for Republicans.

The second major point is that the HB2146 plan generates a significant number of competitive districts. Electoral competitiveness is an essential component of a liberal democracy. The threat of electoral defeat is critical to creating a democratic government in which elected officials are responsive to public opinion and are held accountable for their decisions while in office.[15]

I use two different metrics to measure competitiveness.

The first measure considers a district competitive if both a Democratic and Republican candidate for statewide federal office between 2012-2020 have won a majority of the two-party vote share in that district. Figure 2 shows these districts as green circles. Note how the grey line in each of these districts crosses the 0.50 line, indicating that both Republican and Democratic candidates for statewide office have won a majority of votes in that district. This approach has the virtue of considering the candidate-specific characteristics that a partisan average or index would not measure. For example, particular candidates from either party might outperform their party's average candidate performance. This is important to consider because actual elections are determined by which candidate wins the most votes, not the result of an average of votes cast, and individual elections in individual

[15]Mayhew, David R., 1974. Congress: The Electoral Connection. New Haven, CT: Yale University Press.
Gordon, Sanford C., and Gregory Huber. "The effect of electoral competitiveness on incumbent behavior." Quarterly Journal of Political Science 2, no. 2 (2007): 107-138.
Ansolabehere, Stephen, David Brady, and Morris Fiorina. "The vanishing marginals and electoral responsiveness." British Journal of Political Science 22, no. 1 (1992): 21-38.
Dropp, Kyle, and Zachary Peskowitz. "Electoral security and the provision of constituency service." The Journal of Politics 74, no. 1 (2012): 220-234.

districts are influenced by the characteristics and qualities of individual candidates. Using this metric, there are 6 competitive districts (Districts 16, 8, 17, 7, 6, and 1).

The second measure of competitiveness uses the partisan index and simply looks at districts where the partisan index is within two percentage points of 50% of the two-party vote share. Scholars have often used two percentage points as a heuristic for hyper-close races in which unforeseen or "knife-edge electoral shifts" can change election results.[16] Furthermore, recent studies of the legislative incumbency advantage have suggested a decline in the benefit afforded to incumbents by voters with more recent estimates being between 3 and 4 percentage points, which divided symmetrically would yield roughly 2 points on either side of the 50% vote margin.[17] Using this metric, there are five competitive districts (Districts 8, 17, 7, 6, and 1).

Unlike the first metric described above, this measure of competitiveness is based on the average performance of candidates. Both metrics have their benefits and drawbacks. The virtue of using the average is that it "washes out" the impact of any one particular candidate by aggregating multiple election results together. The virtue of the "bipartisan victories" metric described above is that it captures the fact that particular candidates often perform very differently from what a partisan index would predict. Thus, the virtues of the first are in many ways the drawbacks of the second, and vice versa. As a result, including both presents a more complete picture. In either case, the HB2146 plan creates a substantial number of competitive districts.

A final point to note is that among these competitive districts, four of them lean Democratic. In other words, while both parties will likely win these districts some of the time, Democratic candidates are slightly favored in four of the five (or six depending on the measure of competitiveness) competitive districts in the plan.

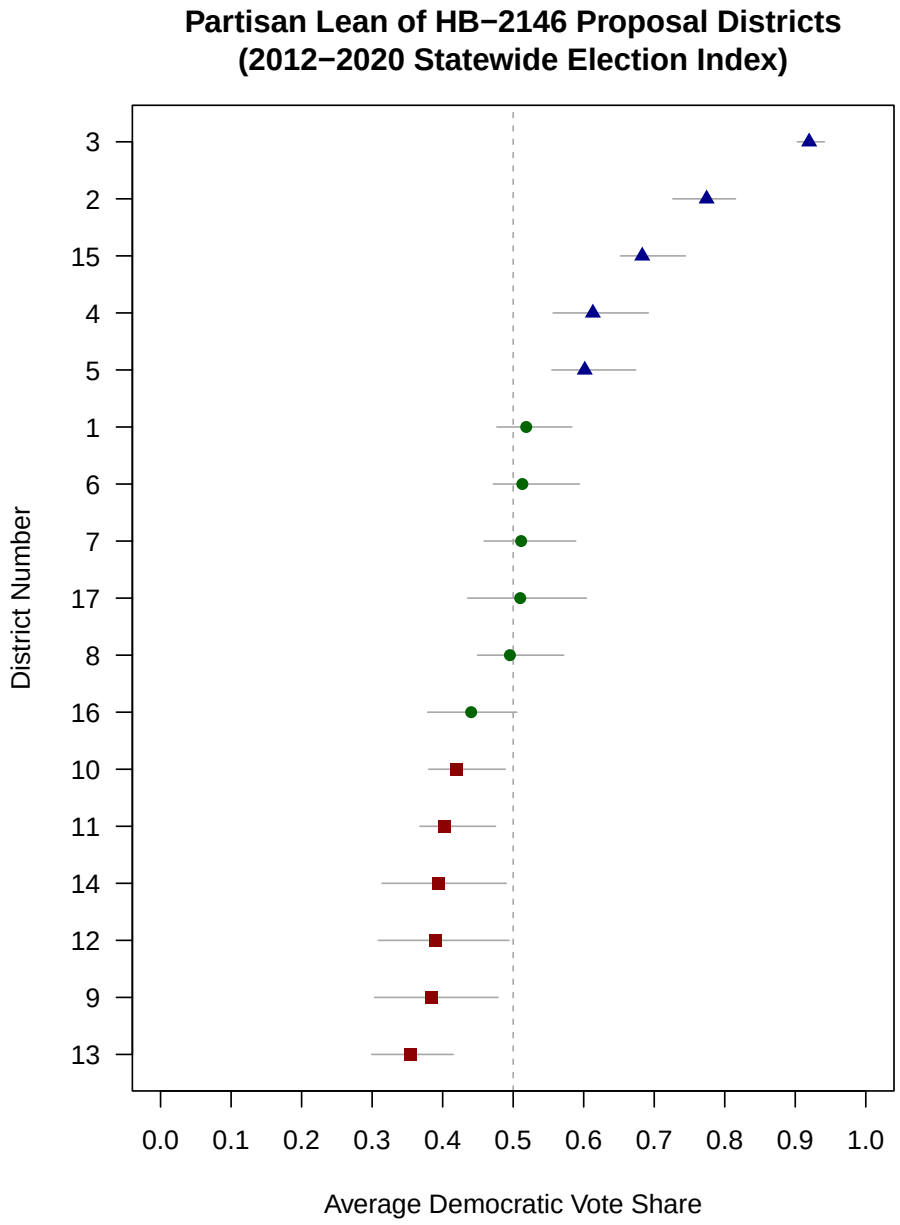
It is important to note that partisan averages — such as the ones I have created here

[16]Erikson, Robert S., and Rocío Titiunik. "Using regression discontinuity to uncover the personal incumbency advantage." Quarterly Journal of Political Science 10, no. 1 (2015): 101-119.

[17]Jacobson, Gary C. "It's nothing personal: The decline of the incumbency advantage in US House elections." The Journal of Politics 77, no. 3 (2015): 861-873.

— are useful, but not perfect. Every congressional race is different. Individual candidate factors such as prior elected experience, professional background, gender, and ties to the local community are all important factors in determining candidate success. Campaigns and the issues and policies that candidates choose to emphasize and endorse are also important. These factors all contribute to making each race unique and slightly different from what an index of statewide election results might predict. In other words, no election will perfectly mirror the partisan average for that district based on an index of election results, and in some cases that difference could be quite large.

Figure 2: **Partisan Index of HB2146 plan Congressional Districts**



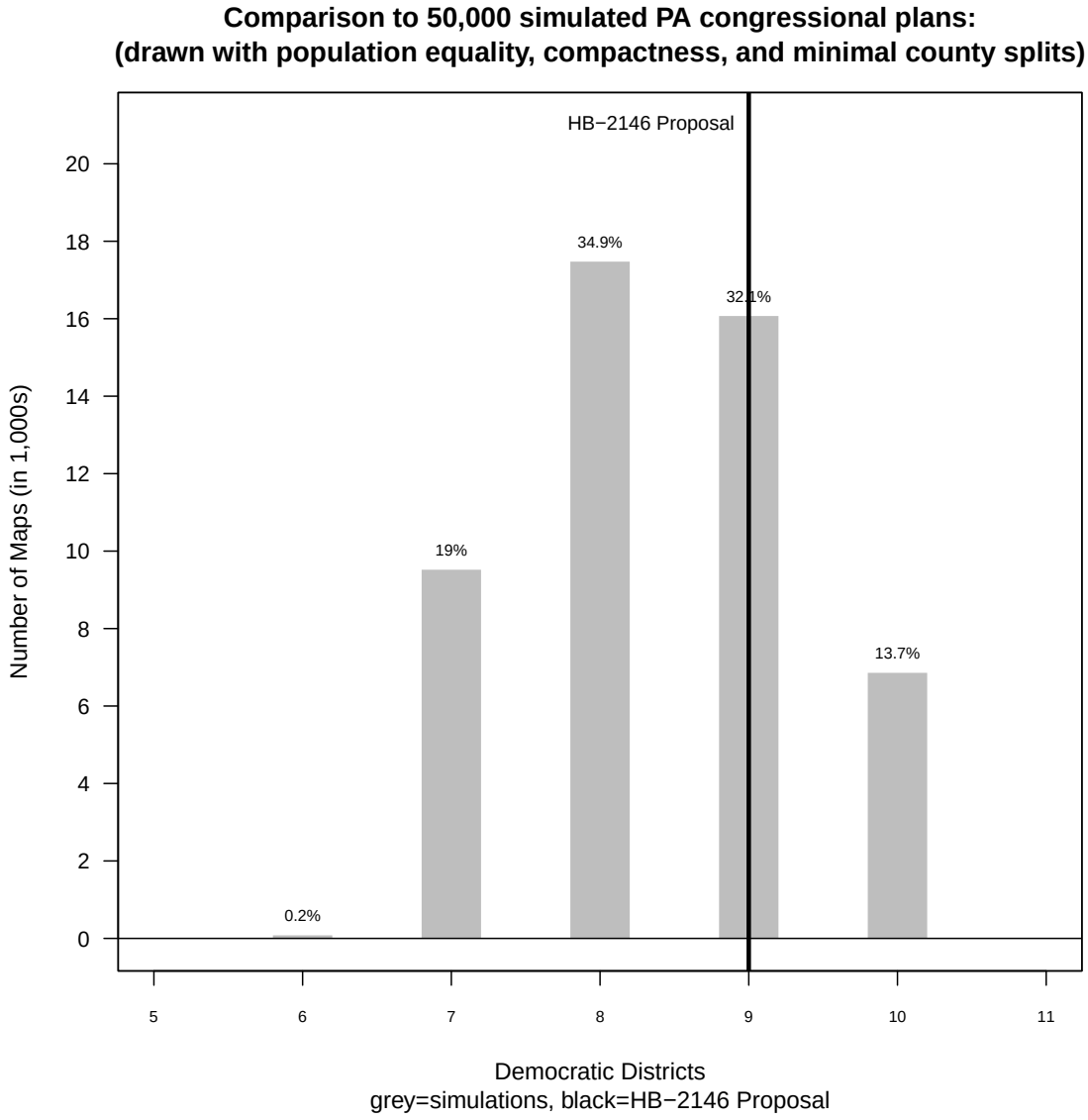
Note: Partisan Index based on the average of statewide partisan races between 2012-2020. Districts with a partisan index less than 0.50 are Republican leaning and districts with a partisan index greater than 0.50 are Democratic leaning. A vertical dashed line is placed at 0.50 for reference. The grey horizontal lines around each point show the range of election outcomes for all of the statewide elections used to generate the index. Districts in which the Republican candidate for statewide elections won the majority of the two-party vote share in all of the statewide races are shown as red triangles (there are 6 of them) while districts where the Democratic candidate for statewide elections won the majority of the two-party vote share in all of the stateside races are shown as blue triangles (there are 5 of them). Districts where both parties have won a majority of the two-party vote share in these statewide races are displayed as green circles (there are 6 of them).

5.3 Partisan Lean of Districts Compared to Simulations

Figure 3 displays the distribution of Democratic-leaning districts in both the simulations and the HB2146 plan using the 2012-2020 partisan index discussed above. If a district in the simulations or in the HB2146 plan has a partisan index greater than 0.50, I call that a Democratic-leaning district. Likewise, if a districts in the simulations has a partisan index less than 0.50, I call that a Republican-leaning district. The grey histogram shows the distribution of Democratic-leaning seats generated by the simulations. The simulations generate between six and ten Democratic-leaning districts, and the numbers above each bar in the histogram display the proportion of simulated maps that generate each outcome. For example, in 34.9% of the simulations there are eight Democratic-leaning districts (and therefore nine Republican-leaning districts). The solid black vertical line shows the results of calculating the partisan index for the HB2146 plan. The HB2146 plan generates nine Democratic leaning districts, which is in line with the distribution of Democratic-leaning seats generated by the simulations (32.1% of the simulations generate this result). As noted above, the most common outcome in the simulations is eight Democratic-leaning seats, which is one less than the HB2146 plan generates.

Recall that in using the simulations we are comparing the proposed map to a set of maps drawn by the computer using only those criteria that I instructed the algorithm to follow - namely the pre-specified nonpartisan criteria of equal population, contiguity, geographic compactness and a preference for fewer county splits. Both the HB2146 plan and the simulations account for the unique political geography of Pennsylvania. Doing so shows us that the HB2146 plan is within the middle portion of simulation results and if anything leans slightly towards the Democratic party by generating nine Democratic-leaning districts rather than eight, which is the modal outcome in the simulations. By no standard definition would the plan be considered an outlier.

Figure 3: **Partisan Composition of HB2146 plan and Simulations**



Note: The grey distribution is the number of Democratic seats generated from the 50,000 simulations. The vertical black line is the number of Democratic leaning seats in the HB2146 plan. The HB2146 plan generates 9 Democratic leaning districts. The partisan lean of districts in the simulations and the HB2146 plan are calculated as the two-party vote share of statewide partisan elections from 2012-2020.

5.4 District-by-District Comparisons

While Figure 3 shows the position of the HB2146 plan in relation to the simulations overall, it is also instructive to look at a district-by-district level to see if any particular district stands out as an outlier. Figure 4 below does this for each of the 17 districts in

the state. The figure plots the partisan lean of each district across all of the simulations ordered from least Democratic at the top to most Democratic at the bottom of the figure. The simulation results are displayed in grey and generate a "cloud" or range of partisan outcomes for each district. The black dots in the figure show the partisan lean of each of the districts in the HB2146 plan and their relative position within the simulations. Next to each district is text showing the position of the HB2146 plan in relation to the simulations. For example, in the most Republican-leaning district (District 13) at the top of the figure, the HB2146 plan is more Democratic than 64% of the simulations in that district.

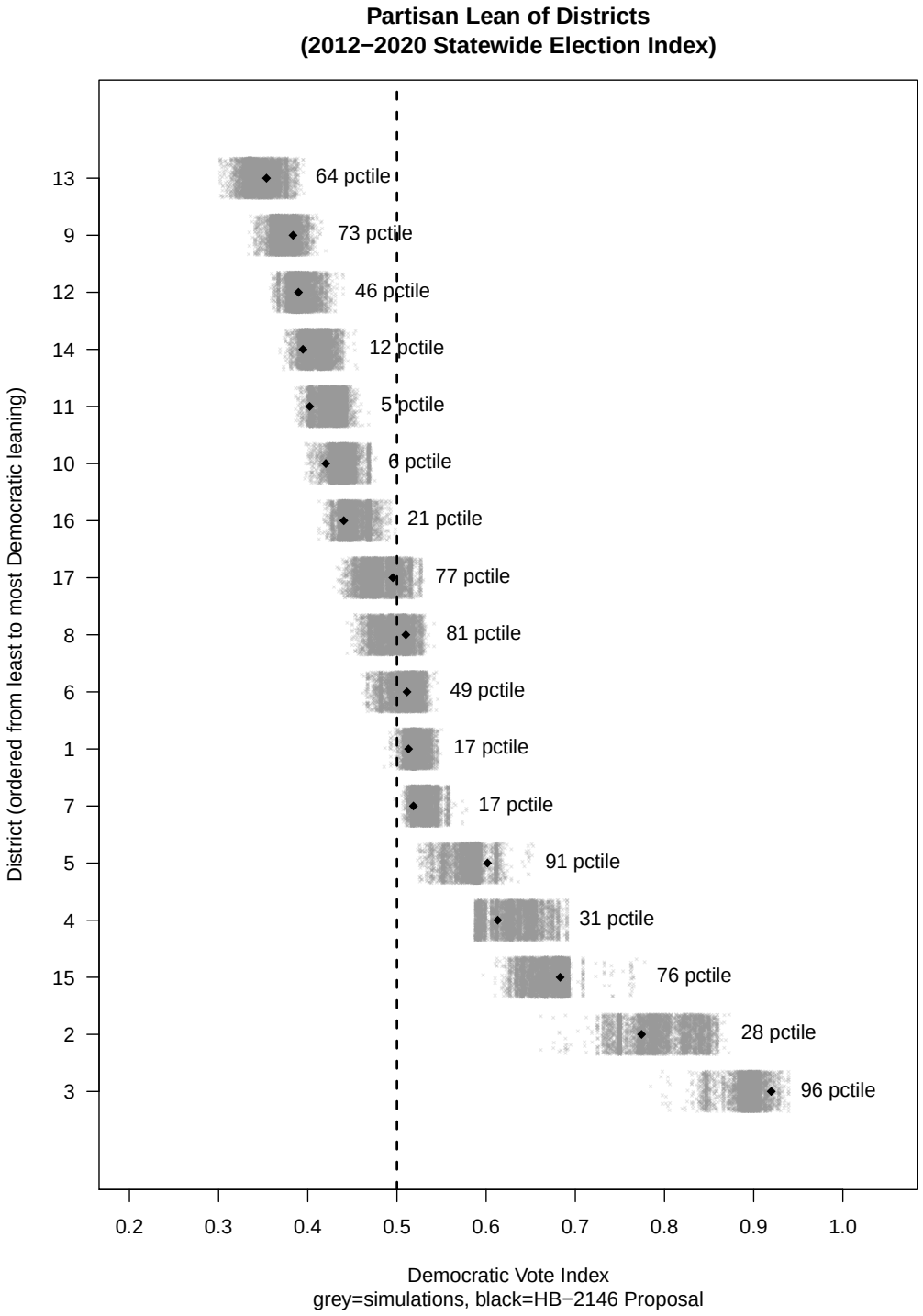
Looking district by district, we see that in most cases the HB2146 plan sits well within the middle of the distribution of simulations. In a few cases it stands out as an outlier, and I consider each of these cases one by one. In the 5th and 6th most Republican districts (Districts 11 and 10 in the HB2146 plan, as labelled on the vertical axis of the figure) the HB2146 plan is at the Republican edge of the simulation results indicating that the HB2146 plan is more Republican than only five and six percent of the simulations in these two districts, respectively. However, both of these districts are squarely Republican leaning, even in the simulations that are more favorable to Democrats.

In the 5th most Republican district (District 11 in the HB2146 plan) the partisan index of the HB2146 plan is 0.40 while the median simulation has a partisan index of 0.42. In other words, District 11 is only two points away from the median simulation in this district, and a partisan index or 0.40 or 0.42 would be a safely Republican districts in either case.

The same is true of the 6th most Republican district in the simulations, which is District 10 in the HB2146 plan. This district has a partisan index of 0.42 in the HB2146 plan while the median simulation has a partisan index of 0.435. In other words, District 10 is only 1.5 percentage points away from the median simulation in this district, and a partisan index or 0.42 or 0.435 would be a safely Republican districts in either case. In other words, in these two districts, the position of the HB2146 plan in relation to the median simulation will have minimal real-world impact on the electoral outcomes in those districts.

As described above, the HB2146 plan produces five districts that are extremely competitive with a partisan index within two percentage points of 0.50 (Districts 17, 8, 6, 1, and 7). In two of those five districts, the proposal is more Democratic than the median partisan index in the simulations (Districts 17 and 8), is very near the median simulation in one of the districts (District 6), and in two of these districts (Districts 1 and 7) the HB2146 plan is more Republican than the median simulation. Thus, in the districts where a shift of a few percentage points really could make a difference in the party that wins a congressional seat, the HB2146 plan is balanced between favoring Democrats in 2 of the districts, Republicans in 2 of the districts, and neither party in 1 of the districts when compared to the distribution of simulation results.

Figure 4: **Partisan Composition of HB2146 plan and Simulations**



Note: The grey 'clusters' show the range of vote margins for each district, ordered from least Democratic to most Democratic in the 50,000 simulations. The black dot inside of each cluster shows the partisan index for the HB2146 plan. Next to each cluster is the percentile, or relative position of the HB2146 plan within each cluster of simulation results for each district.

5.5 Median-Mean Difference

Another common measure of the partisan slant of a districting plan is the median-mean difference.[18] The median-mean measure is calculated by taking the median value of the partisan index across all 17 districts in a plan (the value for which half of the observations are smaller and half the observations are larger) and subtracting from that the mean partisan index (the simple average) of all of the districts from the median. Consider a simple example in which there are three districts in a plan with partisan indices of 0.91, 0.46, and 0.40. To find the median we simply look for the district for which there is one district larger and one district smaller (0.46 in this case). To find the mean, we simply take the average by dividing the sum of the partisan indices by the number of districts. In this case, (0.91+0.46+0.40)/3 = 0.59. The median-mean value would then be 0.46-0.59 = -0.13. As in this example, in Figure 5 I take the Democratic vote share of the median district minus the mean Democratic vote share for all 17 districts in the HB2146 plan. Negative numbers indicate a districting plan that favors Republicans and positive numbers indicate a slant in favor of Democrats.

The median-mean test is essentially a test of skew, or in the context of redistricting packing voters into legislative districts. If voters of one party are packed into few districts, those districts will have very high vote shares for one party and will pull the value of the mean district partisanship away from the district partisan index of the median district.[19] This indicates that the party that is packed into the districts with overwhelming majorities will have a harder time translating their votes into seats.[20]

[18] See Best, Robin E., Shawn J. Donahue, Jonathan Krasno, Daniel B. Magleby, and Michael D. McDonald. "Considering the prospects for establishing a packing gerrymandering standard." Election Law Journal 17, no. 1 (2018): 1-20. Warrington, Gregory S. "A comparison of partisan-gerrymandering measures." Election Law Journal: Rules, Politics, and Policy 18, no. 3 (2019): 262-281. Wang, Samuel S-H. "Three tests for practical evaluation of partisan gerrymandering." Stan. L. Rev. 68 (2016): 1263. McDonald, Michael D., and Robin E. Best. "Unfair partisan gerrymanders in politics and law: A diagnostic applied to six cases." Election Law Journal 14, no. 4 (2015): 312-330.

[19] A helpful analogy is to imagine a representative group of 100 Americans gathered at a restaurant. The median and mean incomes of the 100 customers are likely quite similar. If Bill Gates walks into the restaurant, the median income of the now 101 patrons will not shift by much at all, but the mean income will jump significantly, possibly by several million dollars.

[20] McDonald, Michael D., and Robin E. Best. "Unfair partisan gerrymanders in politics and law: A diagnostic applied to six cases." Election Law Journal 14, no. 4 (2015): 312-330.

One drawback of the median-mean test is that it does not account for the natural clustering of voters that occurs in Pennsylvania and other states. This can be remedied by also computing the median-mean difference for the simulated districting plans that also consider for the geographic distribution of voters in the state. This allows us to make an apples-to-apples comparison that holds the political geography of the state constant. Figure 5 displays the results of the median-mean measure for the simulations (in grey) and the HB2146 plan (solid black line). The fact that the distribution of results from the simulations is mostly less than zero shows that the geography of Pennsylvania leads to a natural advantage for Republicans due to the dense clustering of Democratic voters in Philadelphia and Pittsburgh even when districts are drawn using strictly non-partisan criteria.

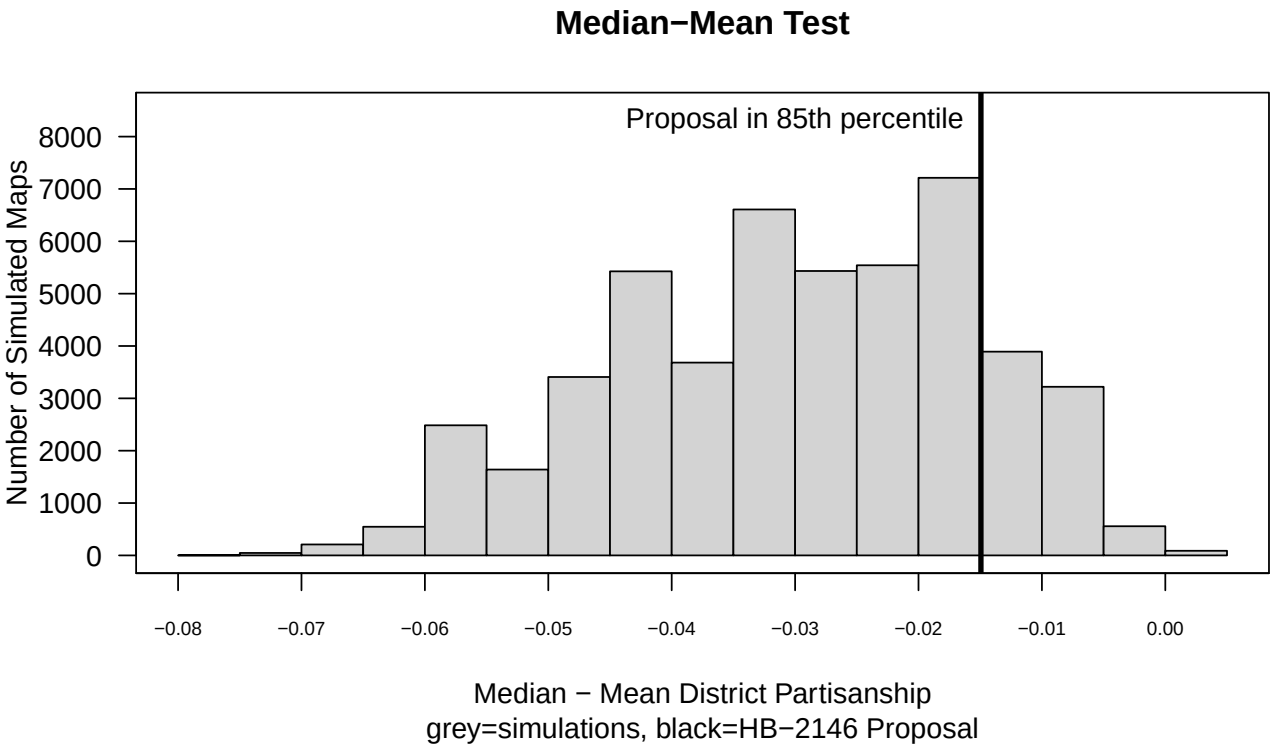
The solid black line shows the results of the HB2146 plan. There are two major points to take away from the results. First, without comparing to the simulations, the HB2146 plan is very nearly unbiased. The median-mean value for the HB2146 plan is -0.015, which is very close to zero.[21] In other words, the median district and the mean district in the HB2146 plan are different by less than two percentage points. Second, when comparing the HB2146 plan to the simulations, the HB2146 plan is more favorable to Democratic voters than the vast majority of the simulated districting plans. The HB2146 plan has a median-mean value that is smaller (in absolute value) than 85 percent of the simulated plans. In other words, using only the non-partisan criteria described above to draw the simulated districts, 85% of them generate districts with a greater median-mean value, indicating a less efficient distribution of Democratic voters than the HB2146 plan contains.

5.6 Efficiency Gap

The efficiency gap is another common redistricting metric and is similar to the median-mean measure in that it looks for the degree to which a party's votes statewide are translated

[21] For example, the congressional plan that was challenged in the *League of Women Voters of Pennsylvania* case in 2017-2018 showed the congressional district plan had a median-mean difference of -0.059. The post-LWV case 2020 congressional plan had a median-mean difference of tktk.

Figure 5: **Median-Mean Measure of HB2146 plan and Simulations**



Note: Values calculated by taking the Democratic partisan index of the median district minus the mean of all 17 districts' partisan indices. Negative numbers indicate a districting plan that favors Republicans and positive numbers indicate a slant in favor of Democrats. The grey histogram shows the results for each of the simulations. The black bar shows the results for the HB2146 plan. The proposal shows very little absolute bias (it is very close to zero) and is more favorable to Democrats than 85% of the simulated districts.

into seats in each district.[22] A description of this measure provided by the Brennen Center for Justice summarizes it well: "[T]he efficiency gap counts the number of votes each party wastes in an election to determine whether either party enjoyed a systematic advantage in turning votes into seats. Any vote cast for a losing candidate is considered wasted, as are all the votes cast for a winning candidate in excess of the number needed to win."[23] In other words, the ideal strategy for a political to maximize the impact of their voters is to distribute

[22]McGhee, Eric. "Measuring efficiency in redistricting." Election Law Journal: Rules, Politics, and Policy 16, no. 4 (2017): 417-442. Veomett, Ellen. "Efficiency gap, voter turnout, and the efficiency principle." Election Law Journal: Rules, Politics, and Policy 17, no. 4 (2018): 249-263. Plener Cover, Benjamin. "Quantifying partisan gerrymandering: An evaluation of the efficiency gap proposal." Stan. L. Rev. 70 (2018): 1131.

[23]`https://www.brennancenter.org/sites/default/files/legal-work/How_the_Efficiency_Gap_Standard_Works.pdf`

them as evenly as possible across districts so as to win by a narrow margin in the district they win and lose by very large margins in the districts where they lose. Put another way, 'win by a little, lose by a lot" is the ideal strategy for a party to maximize their impact of their voters.[24]

The Brennen Center provides a simple example of how the efficiency gap is calculated:

> To understand how the efficiency gap works, consider a hypothetical state with 500 residents that is divided into five legislative districts, each with 100 voters. In the most recent election cycle, Democrats won Districts 1 and 2 by wide margins, while Republicans won Districts 3, 4, and 5 in closer races. Overall, Democratic candidates received 55 percent of the statewide vote but won just 40 percent of the legislative seats, while Republican candidates received 45 percent and won 60 percent of the seats. The table below shows the election results for each district.[25]

District	D votes	R Votes	Result
1	75	25	D wins
2	60	40	D wins
3	43	57	R wins
4	48	52	R wins
5	49	51	R wins
Total:	275	225	

Once we have the election results, the first step is to consider the number of "wasted votes" in each district. Because the Republican candidate in this example lost in District 1, all 25 of the votes cast for that candidates are wasted. The Democratic candidate in District 1 won, but by 24 more votes than would be necessary (since all that is needed is 51 votes to win). Thus, there are 24 wasted Democratic votes in this district. Taking the difference indicates that there was a net of 1 Republican wasted vote in this district.

[24]Of course, parties have other priorities and winning by a single vote might not be their ideal scenario in reality.

[25]https://www.brennancenter.org/sites/default/files/legal-work/How_the_Efficiency_Gap_Standard_Works.pdf

The efficiency gap is then calculated as Efficiency Gap = (Total Democratic Wasted Votes - Total Republican Wasted Votes) / Total Votes. In order to account for uneven turnout across districts and elections, the efficiency gap formula can be re-expressed as the following equation: Efficiency Gap = (Seat Margin – 50%) – 2(Vote Margin – 50%) where the seat margin is the fraction of seats won by Democrats minus 0.50 and the vote margin is the fraction of votes won by Democratic candidates statewide minus 0.50.[26]

In this example and in Figure 5 I use the Democratic seat and vote margins which means that negative efficiency gap numbers indicate a districting plan that favors Republican voters and positive numbers indicate a plan that favors Democratic voters. As with the median-mean test, the efficiency gap has the drawback of not accounting for the natural clustering of Democratic voters in Pennsylvania and other states. However, as before I remedy this by also computing the efficiency gap for the simulated districting plans that also must account for the geographic distribution of voters in the state. This allows us to make an apples-to-apples comparison that accounts for political geography. Figure 6 displays the results of the efficiency-gap measure for the simulations (in grey) and the HB2146 plan (solid black line). The distribution of results from the simulations show that the geography of Pennsylvania leads to a naturally arising advantage for Republicans due to the dense clustering of Democratic voters in Philadelphia and Pittsburgh.[27]

The solid black line shows the results of the HB2146 plan. There are two major points to take away from the results. First, the HB2146 plan is very nearly unbiased. The efficiency gap for the HB2146 plan is -0.02, which is very close to zero.[28] In other words, in the HB2146 plan Democratic votes are not much more likely than Republican votes to be "wasted" across the districts. Second, when comparing the HB2146 plan to the simulations, the HB2146

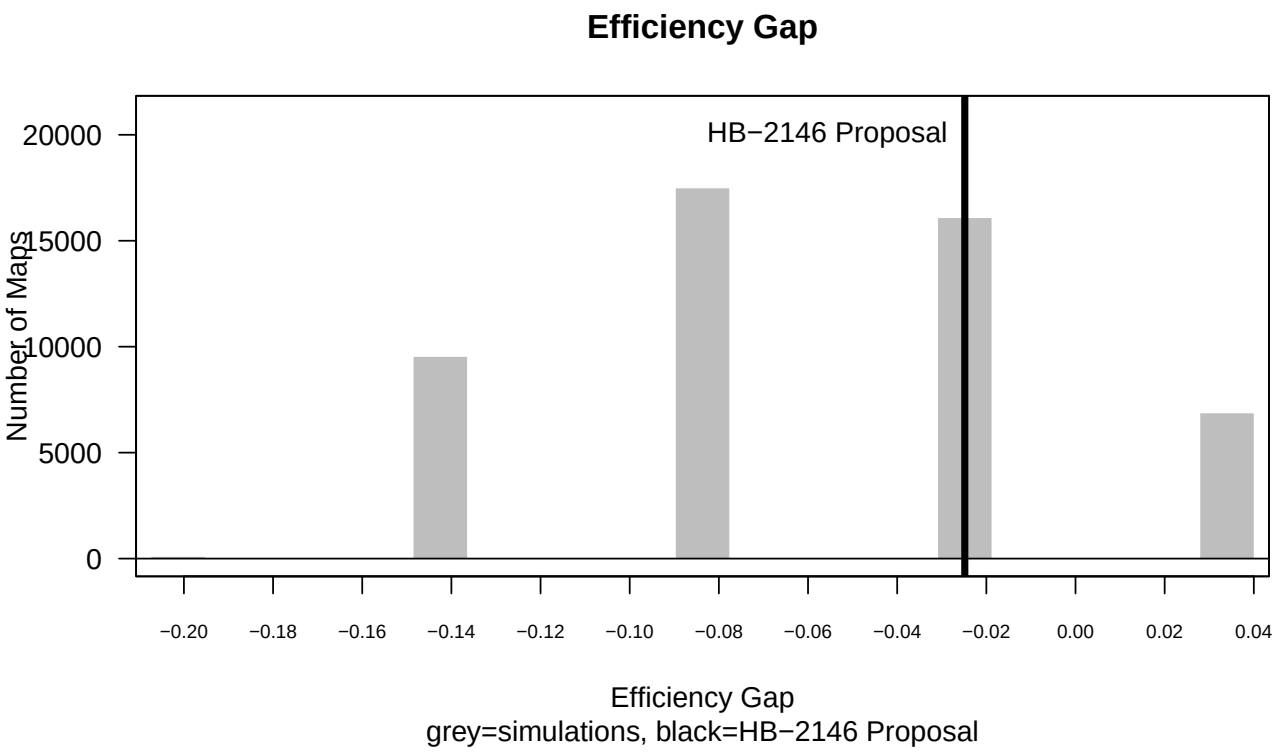
[26]See McGhee, Eric. "Measuring efficiency in redistricting." Election Law Journal: Rules, Politics, and Policy 16, no. 4 (2017): 417-442.

[27]Because the efficiency gap is a measure of seat shares, it will be a 'chunky' measure with values for each seat won or lost in a plan, unlike the median-mean measure which is a more continuous measure that changes based on small changes in the margin of victory in each district.

[28]For example, the congressional plan that was challenged in the *League of Women Voters of Pennsylvania* case in 2018 showed the congressional district plan had a pro-Republican efficiency gap of between -0.15 and -0.20. The post-LWV 2020 congressional map had an efficiency gap of tktk.

plan is more favorable to Democratic voters than the majority of the simulated districting plans. The HB2146 plan has an efficiency gap that is smaller (in absolute value) than all other outcomes in the simulated plans. While some of the simulated plans generate pro-Democratic efficiency gaps, they are larger in absolute terms and would be more biased than the HB2146 plan in favor of Democrats instead of the very slight lean towards Republicans exhibited in the HB2146 plan. In other words, using only the non-partisan criteria described above to draw the simulated districts, the HB2146 plan is in agreement with the least biased outcome in the simulations.

Figure 6: **Efficiency Gap Measure of HB2146 plan and Simulations**



Note: Distribution of efficiency gap among simulations shown in grey and the HB2146 plan shown as the solid black line. Negative values indicate plans that are have a Republican advantage and positive values indicate plans that have a Democratic advantage. The HB2146 plan has a very small efficiency gap of -0.02 and is more favorable to Democratic voters than the majority of the non-partisan simulations, which have larger (more negative) efficiency gap values.

5.7 Expected Seats from Uniform Swing

Another measure of redistricting considers how a plan performs, on average, under a variety of different electoral environments. While the partisan index does this to a degree by averaging across a number of elections and years, I present another measure here where I report the results of applying a randomly chosen uniform swing to the election results in the HB2146 plan and the simulations. A uniform swing is simply a way of asking what would the election results in the districts look like if a certain percentage were added uniformly to each district in the plan.[29] In other words, a uniform swing of 1.3 points in the Democratic direction would simply add 0.013 to the partisan index of each district while a uniform swing of 2.5 points in the Republican direction would simply subtract 0.025 from the partisan index of each district. Of course, a swing of 1 points is more likely than a swing of 5 or 6 points as large wave elections are more rare than elections that perform closer to the average performance of each party. To account for this, I randomly apply 10,000 uniform swings to the simulations and the partisan index of the HB2146 plan and calculate the average of the number of seats that are held by Democrats in the HB2146 plan and each of the 50,000 simulations. The value of the uniform swing is chosen from a normal distribution that is centered at zero with a standard deviation of 3 percentage points.[30] Thus, small swings are more likely than large swings, but large swings of 3, 4, 5, and even 6 percentage points are possible, just as we occasionally observe large electoral waves in national politics. This gives us an idea of how a plan performs, on average, under a variety of potential electoral environments.

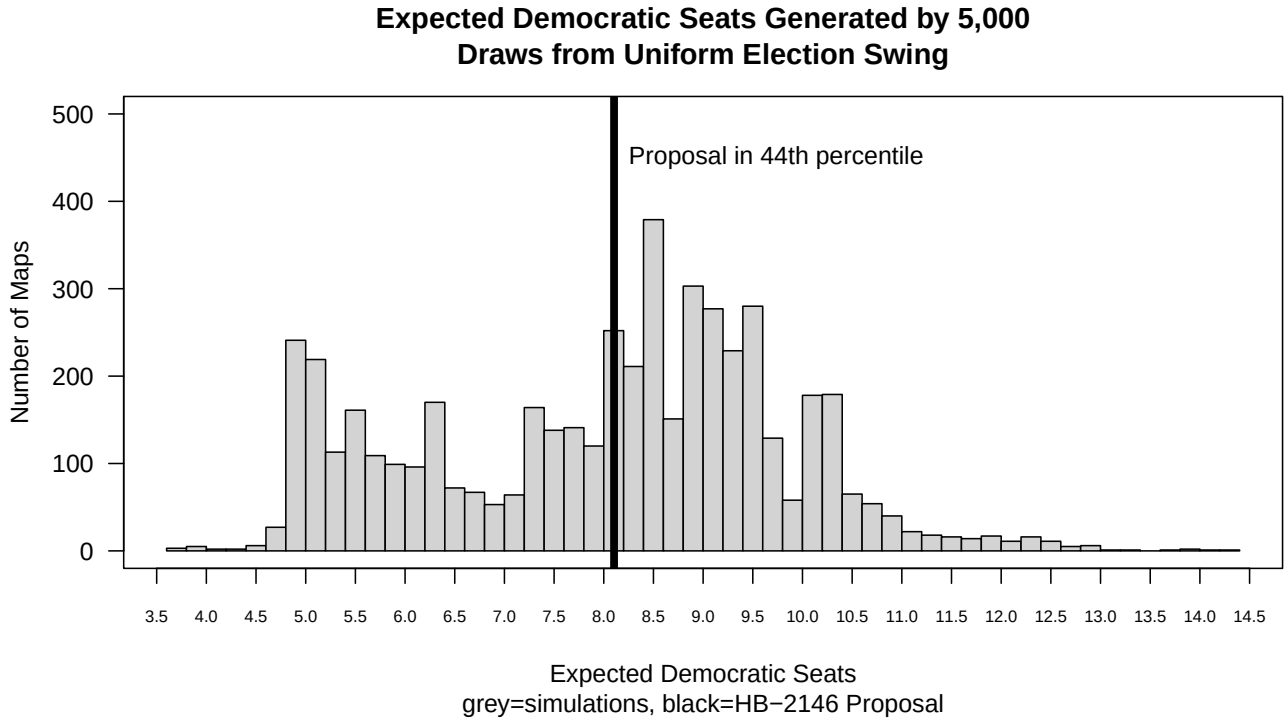
The result of this process is a measure of the expected number of Democratic seats that a plan will produce under a variety of different electoral conditions — some good for

[29] See Jackman, Simon. "The predictive power of uniform swing." PS: Political Science & Politics 47, no. 2 (2014): 317-321 for a discussion of the concept of a uniform swing in elections. See Expert Report of Dr. Wesley Pegden in *Harper v. Hall*, Wake County North Carolina, No. 21 CVS 500085 for another example of using a uniform swing to calculate expected seat shares in redistricting.

[30] 3 percentage points is approximately the standard deviation of all of the statewide election results used in creating the 2012-2020 partisan index.

one party, some good for the other party, and some that are about average for both parties. Figure 7 shows the results of this process. The grey distribution shows the expected number of Democratic seats after applying the 5,000 draws from the uniform swing to the 50,000 simulations. Some of the simulated plans are very favorable to Republicans (with expected Democratic seat shares near 5) while other plans are very favorable to Democrats (with expected seat shares of 12 Democratic seats). The HB2146 plan, however, is nearly exactly in the middle of this distribution. The proposal generates an expected seats of 8.10 and is in the 44th percentile of the distribution of the simulated results. In other words, 44 percent of the simulations are worse for Democrats and 55 percent the simulations are better for Democrats compared to the HB2146 plan. The plan is positioned nearly in the middle of the non-partisan simulations on this measure.

Figure 7: **Expected Seats from Uniform Swing of HB2146 plan and Simulations**



Note: Distribution of expected seats in the HB2146 plan (black line) and the simulations (grey distribution) after applying 5,000 uniform swings to the partisan index. The value of each uniform swing is chosen from a normal distribution that is centered at zero with a standard deviation of 3 percentage points.

5.8 Considerations of Race

Table 3 shows the non-Hispanic Black voting age population percent of each district and the non-White voting age population percent of each district in the HB2146 plan. The districts are ordered from lowest to highest percentage in each category. The HB2146 plan contains one district (District 3) in Philadelphia that is just shy of being majority Black with a 49.82% non-Hispanic Black voting age population. Additionally, District 2 has a 59.60% non-White voting age population. District 15 has a 32.5% non-White voting age population.

Table 2: District-by-District Racial Composition of HB2146 plan

District rank	District Number	NHBVAP	District Number	Non-White
17	12	2.1%	14	7.2%
16	9	2.3%	12	9.0%
15	14	2.4%	16	10.8%
14	11	3.3%	9	11.6%
13	1	3.8%	17	12.2%
12	17	3.9%	13	13.8%
11	16	3.9%	1	18.1%
10	13	4.9%	11	18.1%
9	7	5.2%	8	18.3%
8	6	5.3%	10	20.0%
7	8	5.4%	4	25.6%
6	10	6.8%	6	26.4%
5	4	9.6%	7	27.5%
4	15	17.5%	15	28.3%
3	5	19.2%	5	32.8%
2	2	21.9%	2	57.1%
1	3	52.2%	3	68.6%

One potential criticism that some may raise of the simulations is that they do not take into account racial data when drawing district boundaries, and that once this constraint is imposed it may shift the partisan composition of the remaining districts in a way that the distribution of simulations may look different when racial factors are explicitly considered. This criticism, however, is unwarranted, as the explicit consideration of race, if anything, actually brings the distribution of simulations more in line with the HB2146 plan.

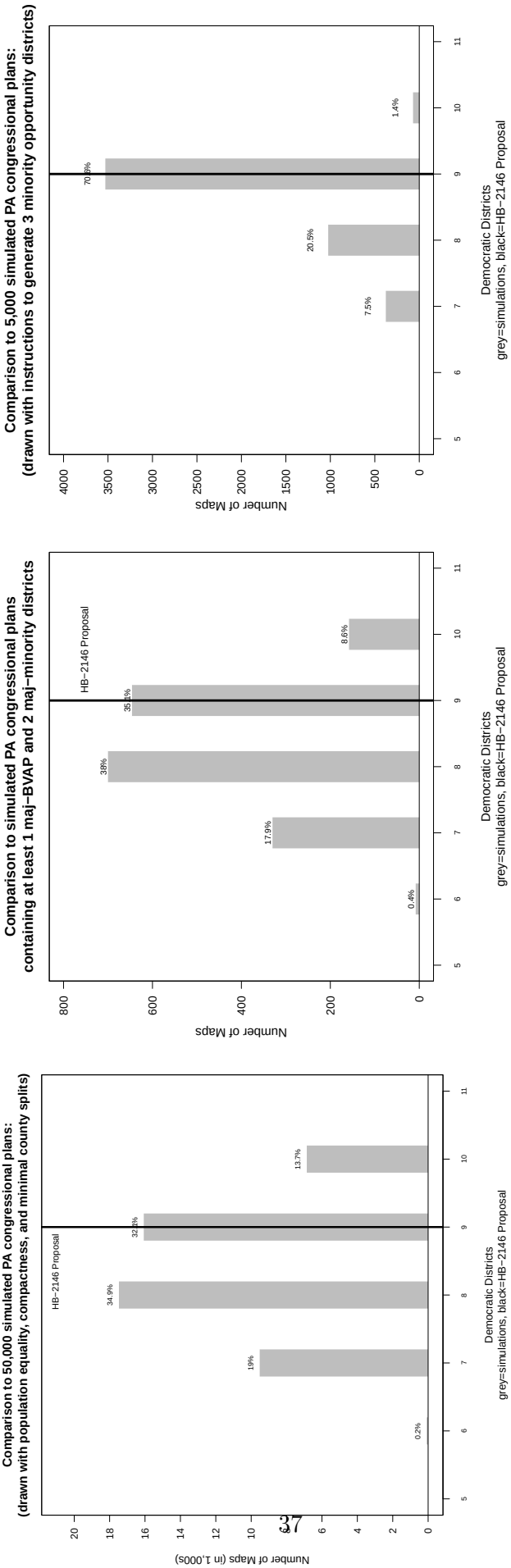
Figure 8 below shows this. The left panel of Figure 8 is the same as Figure 3 in

the earlier section of this report and shows the partisan distribution of the simulations and the location of the HB2146 plan. The middle panel of the figure subsets the race-blind simulations to the 1,842 plans that, while race was not explicitly considered, nevertheless contain both a majority-black district as well as an additional majority-minority district.[31] Comparing the two panels shows that the distributions are extremely similar. The probability of a 9-D map, which is what the HB2146 plan generates, is nearly identical across the two sets of simulations (35.1% in the race-blind simulations, 32.1% in the race-filtered simulations).

The right panel in Figure 8 is the distribution of Democratic-leaning seats derived from a separate set of simulations that explicitly consider race. In this race-conscious set of simulations I instruct the model to ensure that every plan contains three districts that have at least a 35% non-white voting age population. These districts are often referred to as minority oppfortunity districts. I choose to instruct the model to generate three of these districts as it is similar to the number of minority opportunity districts generated by the HB2146 plan and the plans put forward recently by Governor Wolf. Other than the use of racial data to inform the construction of minority opportunity districts, the other parameters and data used in the two sets of simulations are identical in every other way. The right panel of Figure 8 shows that the results of the race-conscious simulations is a general reduction in the variation in the number of Democratic-leaning seats generated by the simulations. The probability of a 7-D or 8-D map has decreased substantially while there are no simulations that generate a 6-D map and only 1.4% of the simulations generate a 10-D map. A map with 9 Democratic-leaning districts is now the most common outcome with 70.6% of the simulations generating this result.

[31]While a reduction from 50,000 to 1,842 simulated plans is substantial, 1,842 is still a large number of plans to compare against and is larger than many simulations presented in other expert reports in recent redistricting litigation and is still large enough to provide a sufficient sample of maps to compare to.

Figure 8: **Seats Carried by Democrats in Race-Blind and Race-Conscious Simulations**



Note: The left panel contains the results of the 50,000 simulations that do not consider race when districts are drawn. The middle panel considers the 1,832 districts that, even though they were drawn without any racial data, nevertheless contain a majority Black district and an additional majority minority district. The right panel is the distribution from 5,000 simulations that are drawn with racial data and instructions to generate three districts with at least a 35% minority voting age population.

6 Conclusion

Based on the evidence and analysis presented above, my opinions regarding the HB2146 plan for congressional districts in Pennsylvania can be summarized as follows:

- The contemporary political geography of Pennsylvania is such that Democratic majorities are geographically clustered in the largest cities of the state while Republican voters dominate the suburban and rural portions of the state.

- This geographic clustering in cities puts the Democratic Party at a natural disadvantage when single-member districts are drawn. Specifically, districts drawn to be contiguous, compact, and contain minimal county and municipal splits will naturally create several districts in the Philadelphia and Pittsburgh areas that contain substantial Democratic majorities with many "wasted votes."

- Based on a comparison between the HB2146 plan, and a set of 50,000 simulated maps, the HB2146 plan is a fair plan with no evidence of partisan gerrymandering across a number of different measures used to assess the fairness of a map.

- Based on an index of statewide elections from 2012-2020, the HB2146 plan generates nine Democratic-leaning districts and eight Republican-leaning districts.

- Based on the same index of statewide elections from 2012-2020, six of the districts in the HB2146 plan will likely be competitive with candidates from both parties having a realistic possibility of winning the seats. Five of these competitive districts are *extremely* competitive, with a partisan index within two percentage points of an even 50/50 split.

- Compared to a second set of simulations that explicitly consider the creation of minority opportunity districts, the HB2146 plan is similarly unbiased. The race-conscious simulations reduce the variation in Democratic-leaning districts substantially, mak-

ing nine Democratic-leaning districts the overwhelmingly most likely outcome in the simulations.

- Based on these commonly-used measures of redistricting fairness, the HB2146 plan is unbiased, and when compared to the simulations on these same metrics is balanced between occasionally having a slight Republican benefit and occasionally providing a slight benefit to Democratic voters.

I am being compensated for my time in preparing this report at an hourly rate of $400/hour. My compensation is in no way contingent on the conclusions reached as a result of my analysis.

Michael Jay Barber

7 Appendix A: Additional Statistics

Table 3: District-by-District Compactness - Polsby-Popper

District rank	District Number	Polsby-Popper
17	6	0.20
16	2	0.23
15	3	0.24
14	14	0.24
13	17	0.24
12	4	0.25
11	5	0.26
10	13	0.29
9	15	0.29
8	9	0.30
7	8	0.35
6	7	0.37
5	1	0.40
4	12	0.42
3	10	0.45
2	16	0.49
1	11	0.50

Split Municipalities:

- Philadelphia*
- Stowe Township, Allegheny County
- Centre Township, Berks County
- Summit Township, Butler County
- East Hanover Township, Butler County
- Stonycreek Township, Cambria County
- West Whiteland Township, Chester County
- Pine Creek Township, Clinton County
- Silver Spring Township, Cumberland County
- Stroud Township, Dauphin County
- Luzerne Borough, Luzerne County
- Horsham Township, Montgomery County
- Buffalo Township, Union County
- Amwell Township, Washington County
- Independence Township, Washington County
- North Franklin Township, Washington County

*Population of the city is larger than a single congressional district and therefore will need to be split between multiple districts.

Split Counties:

- Allegheny County*
- Berks County
- Butler County
- Cambria County
- Chester County
- Clinton County
- Cumberland County
- Dauphin County
- Luzerne County
- Monroe County
- Montgomery County*
- Philadelphia County*
- Snyder County
- Union County
- Washington County

*Population of the county is larger than a single congressional district and therefore will need to be split between multiple districts.

Number of Democratic-leaning Districts using Alternative Election Indices:

- All 2012-2020 statewide elections: 9
- All 2014-2020 statewide elections: 8
- 2016-2020 index used by Dave's Redistricting: 9
- Index used by Planscore.com: 8

Appendix B: Curriculum Vitae

Michael Jay Barber

CONTACT INFORMATION

Brigham Young University
Department of Political Science
724 KMBL
Provo, UT 84602

barber@byu.edu
http://michaeljaybarber.com
Ph: (801) 422-7492

ACADEMIC APPOINTMENTS

Brigham Young University, Provo, UT

August 2020 - present Associate Professor, Department of Political Science
2014 - July 2020 Assistant Professor, Department of Political Science
2014 - present Faculty Scholar, Center for the Study of Elections and Democracy

EDUCATION

Princeton University Department of Politics, Princeton, NJ

Ph.D., Politics, July 2014

- Advisors: Brandice Canes-Wrone, Nolan McCarty, and Kosuke Imai
- Dissertation: "Buying Representation: the Incentives, Ideology, and Influence of Campaign Contributions on American Politics"
- 2015 Carl Albert Award for Best Dissertation, Legislative Studies Section, American Political Science Association (APSA)

M.A., Politics, December 2011

Brigham Young University, Provo, UT

B.A., International Relations - Political Economy Focus, April, 2008

- *Cum Laude*

RESEARCH INTERESTS

American politics, congressional polarization, political ideology, campaign finance, survey research

PUBLICATIONS

19. **"Ideological Disagreement and Pre-emption in Municipal Policymaking"** with Adam Dynes
Forthcoming at *American Journal of Political Science*
18. **"Comparing Campaign Finance and Vote Based Measures of Ideology"**
Forthcoming at *Journal of Politics*
17. **"The Participatory and Partisan Impacts of Mandatory Vote-by-Mail"**, with John Holbein
Science Advances, 2020. Vol. 6, no. 35, DOI: 10.1126/sciadv.abc7685
16. **"Issue Politicization and Interest Group Campaign Contribution Strategies"**, with Mandi Eatough
Journal of Politics, 2020. Vol. 82: No. 3, pp. 1008-1025

15. **"Campaign Contributions and Donors' Policy Agreement with Presidential Candidates"**, with Brandice Canes-Wrone and Sharece Thrower
Presidential Studies Quarterly, 2019, 49 (4) 770–797

14. **"Conservatism in the Era of Trump"**, with Jeremy Pope
Perspectives on Politics, 2019, 17 (3) 719–736

13. **"Legislative Constraints on Executive Unilateralism in Separation of Powers Systems"**, with Alex Bolton and Sharece Thrower
Legislative Studies Quarterly, 2019, 44 (3) 515–548
Awarded the Jewell-Loewenberg Award for best article in the area of subnational politics published in *Legislative Studies Quarterly* in 2019

12. **"Electoral Competitiveness and Legislative Productivity"**, with Soren Schmidt
American Politics Research, 2019, 47 (4) 683–708

11. **"Does Party Trump Ideology? Disentangling Party and Ideology in America"**, with Jeremy Pope
American Political Science Review, 2019, 113 (1) 38–54

10. **"The Evolution of National Constitutions"**, with Scott Abramson
Quarterly Journal of Political Science, 2019, 14 (1) 89–114

9. **"Who is Ideological? Measuring Ideological Responses to Policy Questions in the American Public"**, with Jeremy Pope
The Forum: A Journal of Applied Research in Contemporary Politics, 2018, 16 (1) 97–122

8. **"Status Quo Bias in Ballot Wording"**, with David Gordon, Ryan Hill, and Joe Price
The Journal of Experimental Political Science, 2017, 4 (2) 151–160.

7. **"Ideologically Sophisticated Donors: Which Candidates Do Individual Contributors Finance?"**, with Brandice Canes-Wrone and Sharece Thrower
American Journal of Political Science, 2017, 61 (2) 271–288.

6. **"Gender Inequalities in Campaign Finance: A Regression Discontinuity Design"**, with Daniel Butler and Jessica Preece
Quarterly Journal of Political Science, 2016, Vol. 11, No. 2: 219–248.

5. **"Representing the Preferences of Donors, Partisans, and Voters in the U.S. Senate"**
Public Opinion Quarterly, 2016, 80: 225–249.

4. **"Donation Motivations: Testing Theories of Access and Ideology"**
Political Research Quarterly, 2016, 69 (1) 148–160.

3. **"Ideological Donors, Contribution Limits, and the Polarization of State Legislatures"**
Journal of Politics, 2016, 78 (1) 296–310.

2. **"Online Polls and Registration Based Sampling: A New Method for Pre-Election Polling"** with Quin Monson, Kelly Patterson and Chris Mann.
Political Analysis 2014, 22 (3) 321–335.

1. **"Causes and Consequences of Political Polarization"** In *Negotiating Agreement in Politics*. Jane Mansbridge and Cathie Jo Martin, eds., Washington, DC: American Political Science Association: 19–53. with Nolan McCarty. 2013.

- Reprinted in *Solutions to Political Polarization in America*, Cambridge University Press. Nate Persily, eds. 2015
- Reprinted in *Political Negotiation: A Handbook*, Brookings Institution Press. Jane Mansbridge and Cathie Jo Martin, eds. 2015

Available Working Papers

"Misclassification and Bias in Predictions of Individual Ethnicity from Administrative Records" (Revise and Resubmit at *American Political Science Review*)

"Taking Cues When You Don't Care: Issue Importance and Partisan Cue Taking"
with Jeremy Pope (Revise and Resubmit)

"A Revolution of Rights in American Founding Documents"
with Scott Abramson and Jeremy Pope (Conditionally Accepted)

"410 Million Voting Records Show the Distribution of Turnout in America Today"
with John Holbein (Revise and Resubmit)

"Partisanship and Trolleyology"
with Ryan Davis (Under Review)

"Who's the Partisan: Are Issues or Groups More Important to Partisanship?"
with Jeremy Pope (Revise and Resubmit)

"Race and Realignment in American Politics"
with Jeremy Pope (Revise and Resubmit)

"The Policy Preferences of Donors and Voters"

"Estimating Neighborhood Effects on Turnout from Geocoded Voter Registration Records."
with Kosuke Imai

"Super PAC Contributions in Congressional Elections"

Works in Progress

"Collaborative Study of Democracy and Politics"
with Brandice Canes-Wrone, Gregory Huber, and Joshua Clinton

"Preferences for Representational Styles in the American Public"
with Ryan Davis and Adam Dynes

"Representation and Issue Congruence in Congress"
with Taylor Petersen

"Education, Income, and the Vote for Trump"
with Edie Ellison

Invited Presentations

"Are Mormons Breaking Up with Republicanism? The Unique Political Behavior of Mormons in the 2016 Presidential Election"

- Ivy League LDS Student Association Conference - Princeton University, November 2018, Princeton, NJ

"Issue Politicization and Access-Oriented Giving: A Theory of PAC Contribution Behavior"

- Vanderbilt University, May 2017, Nashville, TN

"Lost in Issue Space? Measuring Levels of Ideology in the American Public"

- Yale University, April 2016, New Haven, CT

"The Incentives, Ideology, and Influence of Campaign Donors in American Politics"

- University of Oklahoma, April 2016, Norman, OK

"Lost in Issue Space? Measuring Levels of Ideology in the American Public"

- University of Wisconsin - Madison, February 2016, Madison, WI

"Polarization and Campaign Contributors: Motivations, Ideology, and Policy"

- Hewlett Foundation Conference on Lobbying and Campaign Finance, October 2014, Palo Alto, CA

"Ideological Donors, Contribution Limits, and the Polarization of State Legislatures"

- Bipartisan Policy Center Meeting on Party Polarization and Campaign Finance, September 2014, Washington, DC

"Representing the Preferences of Donors, Partisans, and Voters in the U.S. Senate"

- Yale Center for the Study of American Politics Conference, May 2014, New Haven, CT

Conference Presentations

Washington D.C. Political Economy Conference (PECO):

- 2017 discussant

American Political Science Association (APSA) Annual Meeting:

- 2014 participant and discussant, 2015 participant, 2016 participant, 2017 participant, 2018 participant

Midwest Political Science Association (MPSA) Annual Meeting:

- 2015 participant and discussant, 2016 participant and discussant, 2018 participant

Southern Political Science Association (SPSA) Annual Meeting:

- 2015 participant and discussant, 2016 participant and discussant, 2017 participant

Teaching Experience

Poli 315: Congress and the Legislative Process

- Fall 2014, Winter 2015, Fall 2015, Winter 2016, Summer 2017

Poli 328: Quantitative Analysis

- Winter 2017, Fall 2017, Fall 2019, Winter 2020, Fall 2020, Winter 2021

Poli 410: Undergraduate Research Seminar in American Politics

- Fall 2014, Winter 2015, Fall 2015, Winter 2016, Summer 2017

Awards and Grants

2019 BYU Mentored Environment Grant (MEG), American Ideology Project, $30,000

2017 BYU Political Science Teacher of the Year Award

2017 BYU Mentored Environment Grant (MEG), Funding American Democracy Project, $20,000

2016 BYU Political Science Department, Political Ideology and President Trump (with Jeremy Pope), $7,500

2016 BYU Office of Research and Creative Activities (ORCA) Student Mentored Grant x 3

- Hayden Galloway, Jennica Peterson, Rebecca Shuel

2015 BYU Office of Research and Creative Activities (ORCA) Student Mentored Grant x 3

- Michael-Sean Covey, Hayden Galloway, Sean Stephenson

2015 BYU Student Experiential Learning Grant, American Founding Comparative Constitutions Project (with Jeremy Pope), $9,000

2015 BYU Social Science College Research Grant, $5,000

2014 BYU Political Science Department, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), $3,000

2014 BYU Social Science College Award, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), $3,000

2014 BYU Center for the Study of Elections and Democracy, 2014 Washington DC Mayoral Pre-Election Poll (with Quin Monson and Kelly Patterson), $2,000

2012 Princeton Center for the Study of Democratic Politics Dissertation Improvement Grant, $5,000

2011 Princeton Mamdouha S. Bobst Center for Peace and Justice Dissertation Research Grant, $5,000

2011 Princeton Political Economy Research Grant, $1,500

Other Scholarly Activities

Expert Witness in Nancy Carola Jacobson, et al., Plaintiffs, vs. Laurel M. Lee, et al., Defendants. Case No. 4:18-cv-00262 MW-CAS (U.S. District Court for the Northern District of Florida)

Expert Witness in Common Cause, et al., Plaintiffs, vs. LEWIS, et al., Defendants. Case No. 18-CVS-14001 (Wake County, North Carolina)

Expert Witness in Kelvin Jones, et al., Plaintiffs, v. Ron DeSantis, et al., Defendants, Consolidated Case No. 4:19-cv-300 (U.S. District Court for the Northern District of Florida)

Expert Witness in Community Success Initiative, et al., Plaintiffs, v. Timothy K. Moore, et al., Defendants, Case No. 19-cv-15941 (Wake County, North Carolina)

Expert Witness in Richard Rose et al., Plaintiffs, v. Brad Raffensperger, Defendant, Civil Action No. 1:20-cv-02921-SDG (U.S. District Court for the Northern District of Georgia)

Georgia Coalition for the People's Agenda, Inc., et. al., Plaintiffs, v. Brad Raffensberger, Defendant. Civil Action No. 1:18-cv-04727-ELR (U.S. District Court for the Northern District of Georgia)

Expert Witness in Alabama, et al., Plaintiffs, v. United States Department of Commerce; Gina Raimondo, et al., Defendants. Case No. CASE No. 3:21-cv-00211-RAH-ECM-KCN (U.S. District Court for the Middle District of Alabama Eastern Division)

Expert Witness in League of Women Voters of Ohio, et al., Relators, v. Ohio Redistricting Commission, et al., Respondents. Case No. 2021-1193 (Supreme Court of Ohio)

Expert Witness in Regina Adams, et al., Relators, v. Governor Mike DeWine, et al., Respondents. Case No. 2021-1428 (Supreme Court of Ohio)

Expert Witness in Rebecca Harper, et al., Plaintiffs, v. Representative Destin Hall, et al., Defendants (Consolidated Case). Case No. 21 CVS 500085 (Wake County, North Carolina)

Additional Training	EITM 2012 at Princeton University - Participant and Graduate Student Coordinator
Computer Skills	Statistical Programs: R, Stata, SPSS, parallel computing

Updated January 7, 2022

EXHIBIT I

IN THE COMMONWEALTH COURT OF PENNSYLVANIA

No. 464 M.D. 2021

Carol Ann Carter; Monica Parrilla; Rebecca Poyourow; William Tung; Roseanne Milazzo; Burt Siegel; Susan Cassanelli; Lee Cassanelli; Lynn Wachman; Michael Guttman; Maya Fonkeu; Brady Hill; Mary Ellen Balchunis; Tom DeWall; Stephanie McNulty; and Janet Temin,

Petitioners,

vs.

Leigh Chapman, in Her Capacity as Acting Secretary of the Commonwealth of Pennsylvania; and Jessica Mathis, in Her Capacity as Director of the Bureau of Election Services and Notaries,

Respondents.

No. 465 M.D. 2021

Philip T. Gressman; Ron Y. Donagi; Kristopher R. Tapp; Pamela A. Gorkin; David P. Marsh; James L. Rosenberger; Amy Myers; Eugene Boman; Gary Gordon; Liz McMahon; Timothy G. Feeman; and Garth Isaak

Petitioners,

vs.

Leigh Chapman, in Her Capacity as Acting Secretary of the Commonwealth of Pennsylvania; and Jessica Mathis, in Her Capacity as Director of the Bureau of Election Services and Notaries,

Respondents.

AFFIDAVIT OF BILL SCHALLER

I, Bill Schaller, depose and state the following:

1. I am over eighteen years of age and I have personal knowledge of the matters set forth herein.

2. I am employed as Director of Republican Reapportionment Department for the Republican Caucus of the Pennsylvania House of Representatives, and have been employed by the Pennsylvania House of Representatives for 26.5 years.

3. As part of my responsibilities, I am familiar with the congressional redistricting plan passed by the Pennsylvania House of Representatives, House Bill 2146, in the 2021-2022 Session thereof.

4. A true, accurate, and complete rendering of the plan is attached hereto as Exhibit 1.

5. Our office received from the Legislative Data Processing Center (the "LDPC") of the Pennsylvania General Assembly a report that analyzes House Bill 2146. This report was prepared in the ordinary course of business by a person with knowledge, and it is reliable. A true, accurate, and complete copy of the LDPC report is attached hereto as Exhibit 2.

6. A staff member under my direct supervision used our Autobound Edge GIS software to produce a report of the compactness of the House Bill 2146

congressional plan. This report was prepared in the ordinary course of business by a person with knowledge, and it is reliable. A true, accurate, and complete copy of this report is attached hereto as Exhibit 3.

7. A staff member under my direct supervision used our Autobound Edge GIS software to produce a report of the precinct split population breakdowns by district in the House Bill 2146 plan. This report was prepared in the ordinary course of business by a person with knowledge, and it is reliable. A true, accurate, and complete copy of this report is attached hereto as Exhibit 4.

I hereby verify that the foregoing is true and correct to the best of my knowledge, information, and belief. This verification is made subject to the penalties of 18 Pa.C.S. § 4904, relating to unsworn falsification to authorities.

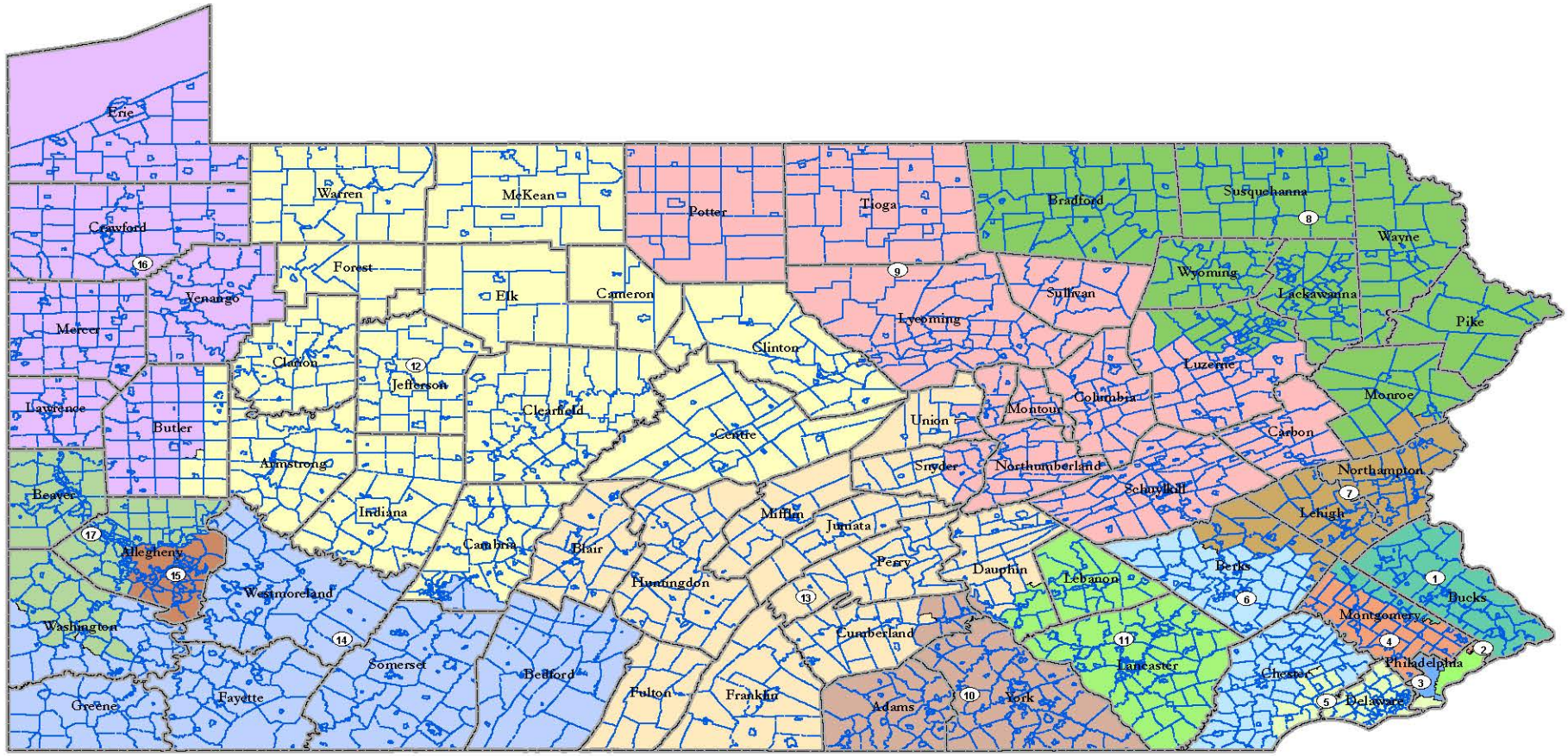
January 24, 2022
Harrisburg, PA

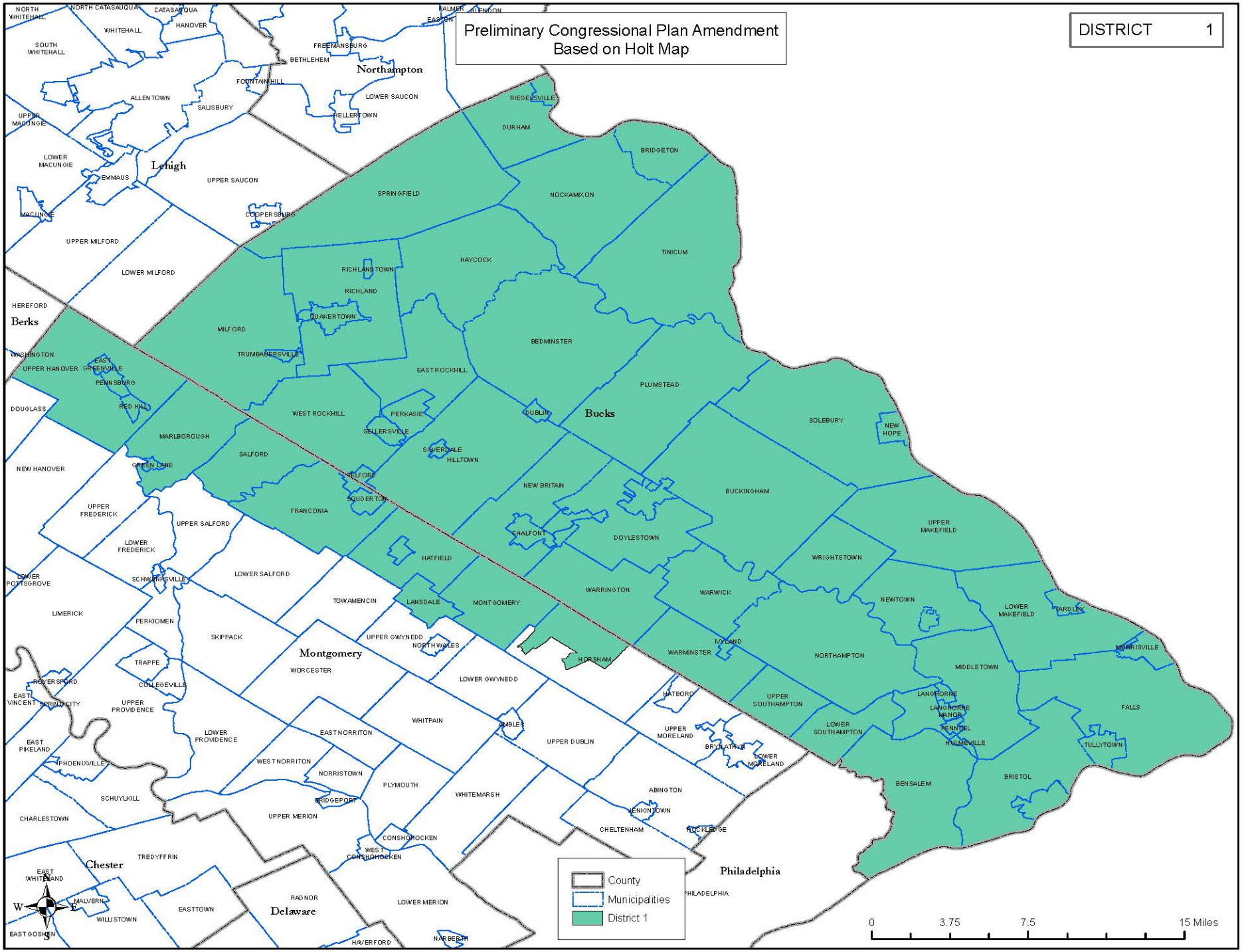
Bill Schaller
Bill Schaller

122042.000003 4889-9930-6763

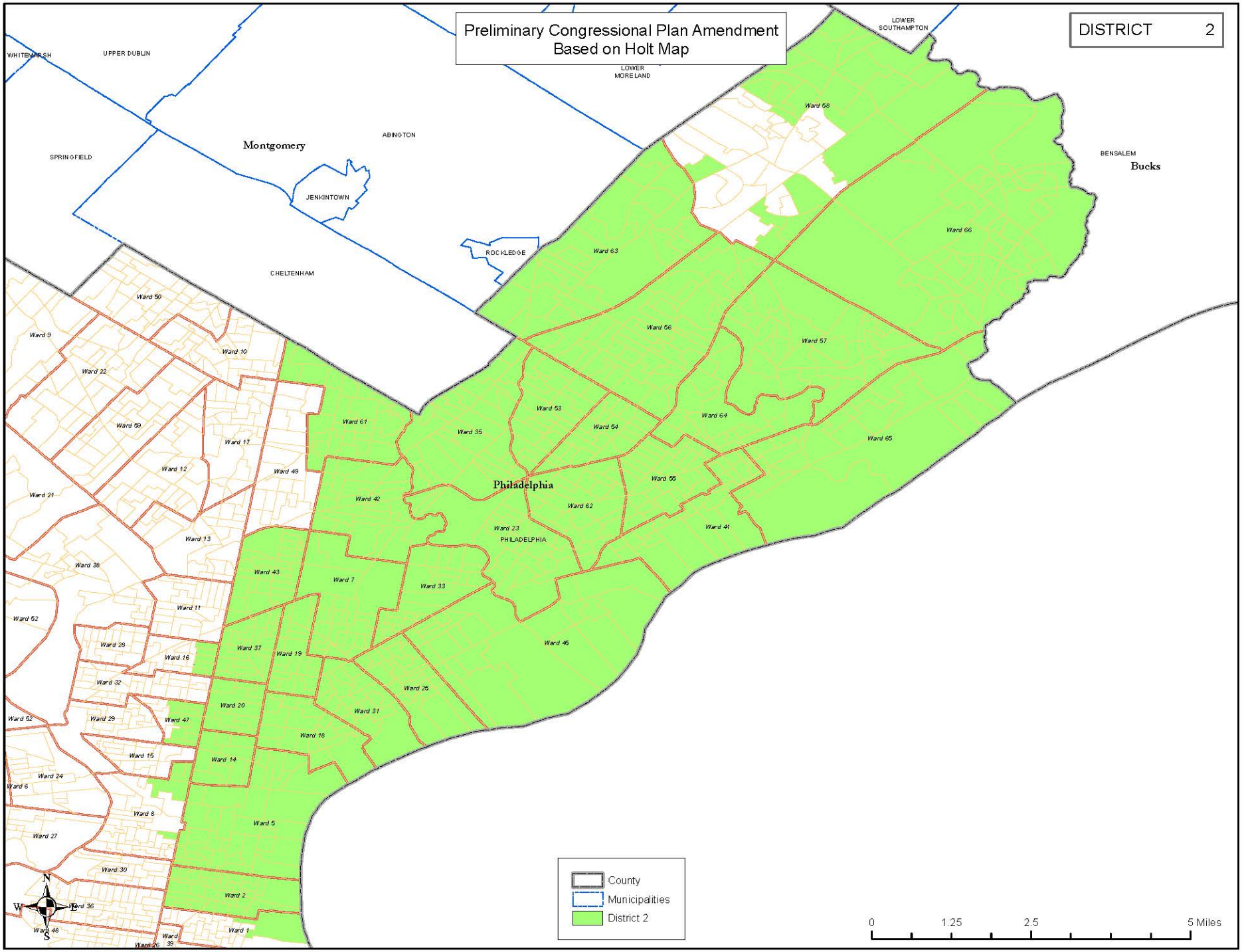
Exhibit 1

Preliminary Congressional Plan Amendment
Based on Holt Map




Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 1
Northampton
Lehigh
Berks
Bucks
Montgomery
Chester
Delaware
Philadelphia
NORTH WHITEHALL
NORTH CATASAUQUA
CATASAUQUA
WHITEHALL
HANOVER
SOUTH WHITEHALL
FREEMANSBURG
BETHLEHEM
EASTON
FOUNTAINHILL
ALLENTOWN
SALISBURY
LOWER SAUCON
HELLERTOWN
RIEGELSVILLE
DURHAM
BRIDGETON
UPPER MACUNGIE
LOWER MACUNGIE
EMMAUS
UPPER SAUCON
SPRINGFIELD
NOCKAMIXON
MACUNGIE
COOPERSBURG
UPPER MILFORD
LOWER MILFORD
HAYCOCK
TINICUM
RICHLANDTOWN
RICHLAND
QUAKERTOWN
HEREFORD
MILFORD
BEDMINSTER
WASHINGTON
TRUMBAUERSVILLE
EAST GREENVILLE
UPPER HANOVER
PENNSBURG
EAST ROCKHILL
PLUMSTEAD
DOUGLASS
RED HILL
WEST ROCKHILL
PERKASIE
DUBLIN
SOLEBURY
NEW HOPE
MARLBOROUGH
SELLERSVILLE
SILVERDALE
HILLTOWN
SALFORD
NEW HANOVER
GREEN LANE
TELFORD
NEW BRITAIN
BUCKINGHAM
SQUDERTON
UPPER FREDERICK
FRANCONIA
UPPER MAKEFIELD
UPPER SALFORD
CHALFONT
DOYLESTOWN
LOWER FREDERICK
WRIGHTSTOWN
HATFIELD
LOWER POTTSGROVE
SCHWENKSVILLE
LOWER SALFORD
WARRINGTON
WARWICK
NEWTOWN
LOWER MAKEFIELD
TOWAMENCIN
LANSDALE
MONTGOMERY
TARDLEY
LIMERICK
PERKIOMEN
UPPER GWYNEDD
NORTH WALES
MYLAND
MORRISVILLE
SKIPPACK
WARMINSTER
NORTHAMPTON
HORSHAM
TRAPPE
WORCESTER
MIDDLETOWN
LOWER GWYNEDD
COLLEGEVILLE
HATBORO
UPPER SOUTHAMPTON
LANGHORNE
LANGHORNE MANOR
FALLS
EAST VINCENT
SPRING CITY
UPPER PROVIDENCE
WHITPAIN
AMBLER
UPPER MORELAND
PENNDEL
HULMEVILLE
TULLYTOWN
EAST PIKELAND
LOWER PROVIDENCE
EAST NORRITON
UPPER DUBLIN
BRYN ATHYN
LOWER MORELAND
LOWER SOUTHAMPTON
PHOENIXVILLE
WEST NORRITON
NORRISTOWN
PLYMOUTH
ABINGTON
BENSALEM
BRISTOL
SCHUYLKILL
BRIDGEPORT
WHITEMARSH
JENKINTOWN
CHARLESTOWN
UPPER MERION
CHELTENHAM
ROCKLEDGE
CONSHOHOCKEN
WEST CONSHOHOCKEN
TREDYFFRIN
EAST WHITELAND
MALVERN
WILLISTOWN
EASTTOWN
RADNOR
LOWER MERION
EAST GOSHEN
HAVERFORD
NARBERTH
PHILADELPHIA
County
Municipalities
District 1
0
3.75
7.5
15 Miles

A191


Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 2
WHITEMARSH
UPPER DUBLIN
LOWER SOUTHAMPTON
LOWER MORELAND
ABINGTON
Montgomery
SPRINGFIELD
JENKINTOWN
ROCKLEDGE
CHELTENHAM
BENSALEM
Bucks
Philadelphia
PHILADELPHIA
Ward 50
Ward 9
Ward 10
Ward 22
Ward 59
Ward 17
Ward 12
Ward 49
Ward 21
Ward 13
Ward 38
Ward 11
Ward 52
Ward 28
Ward 16
Ward 32
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Ward 36
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Ward 26
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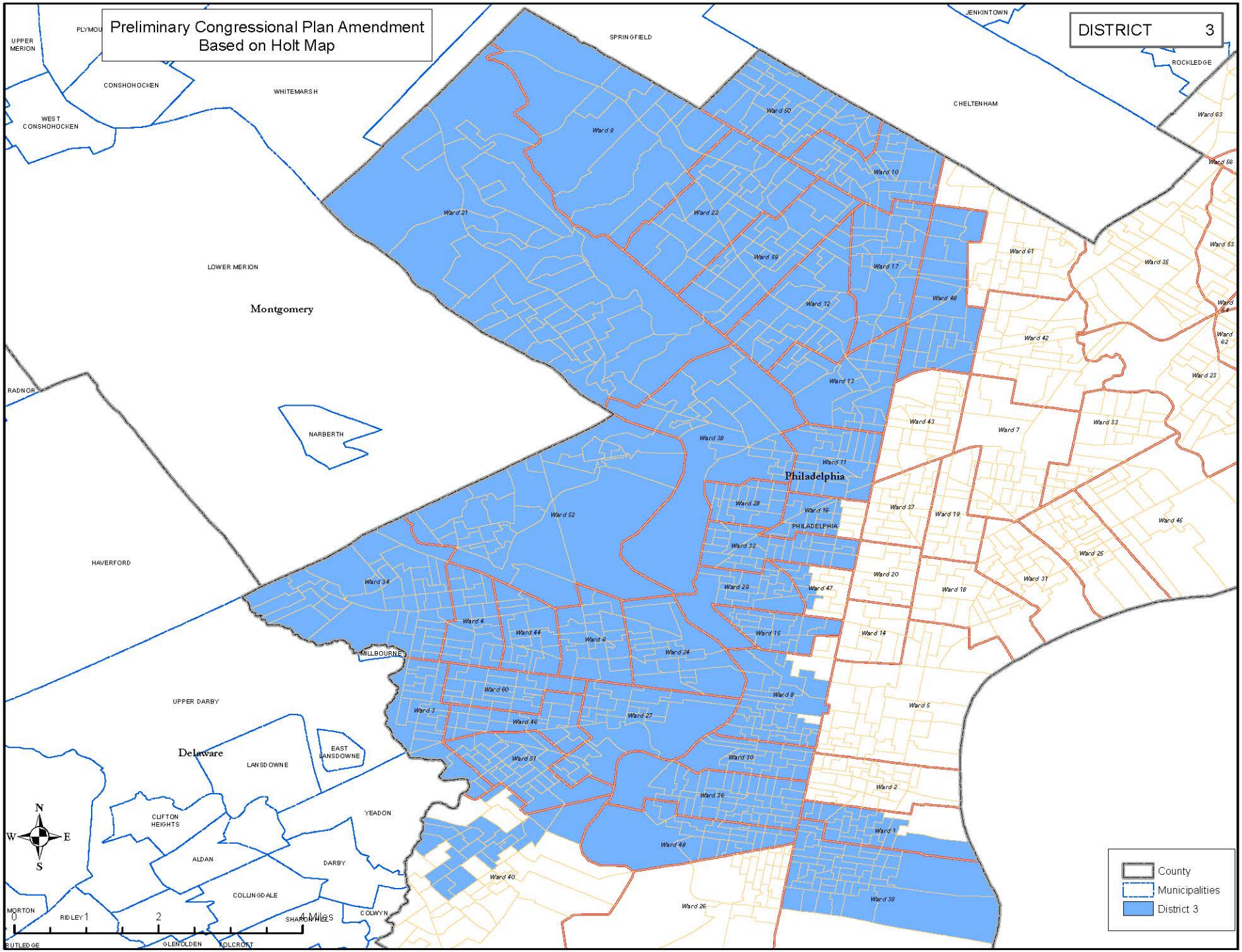
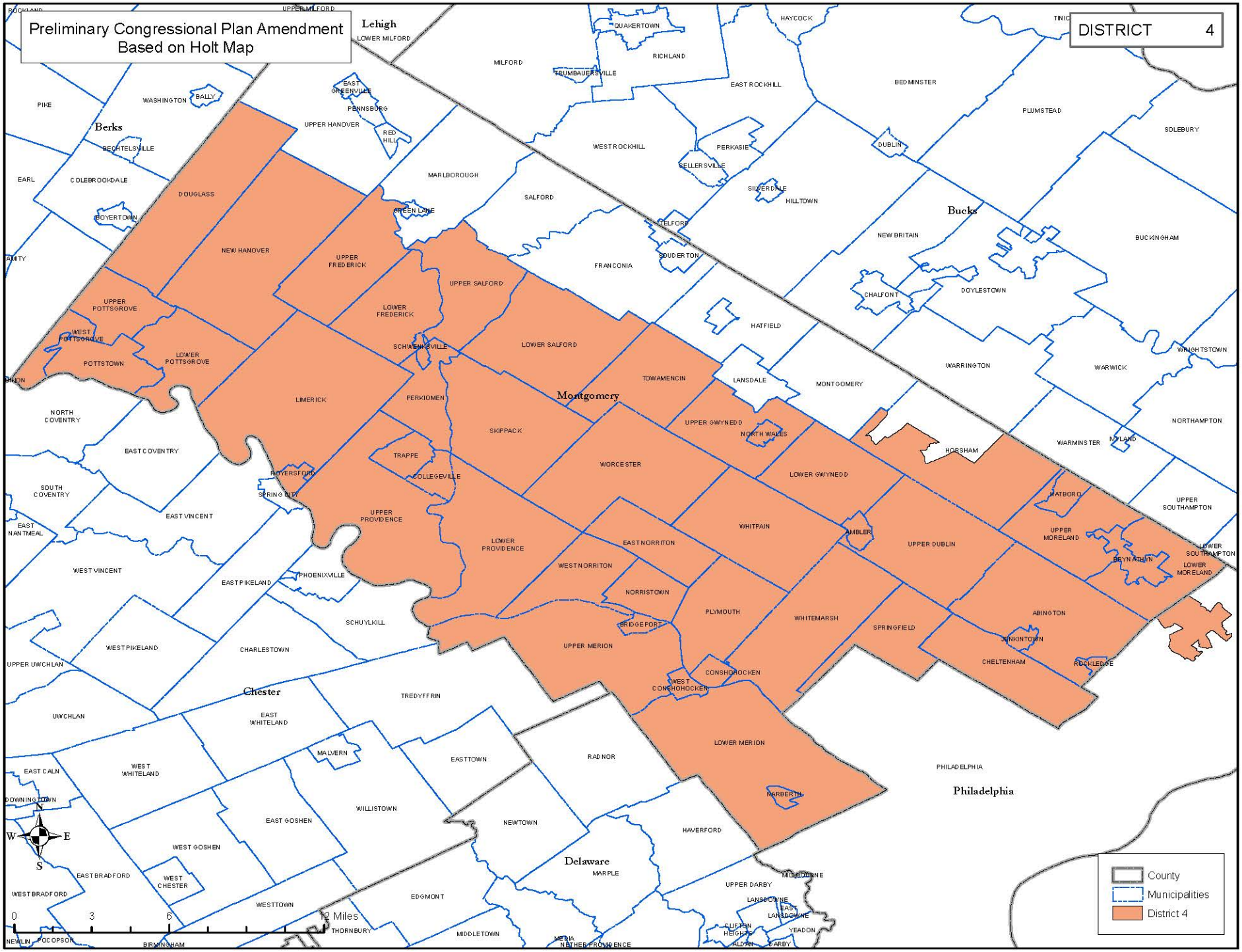
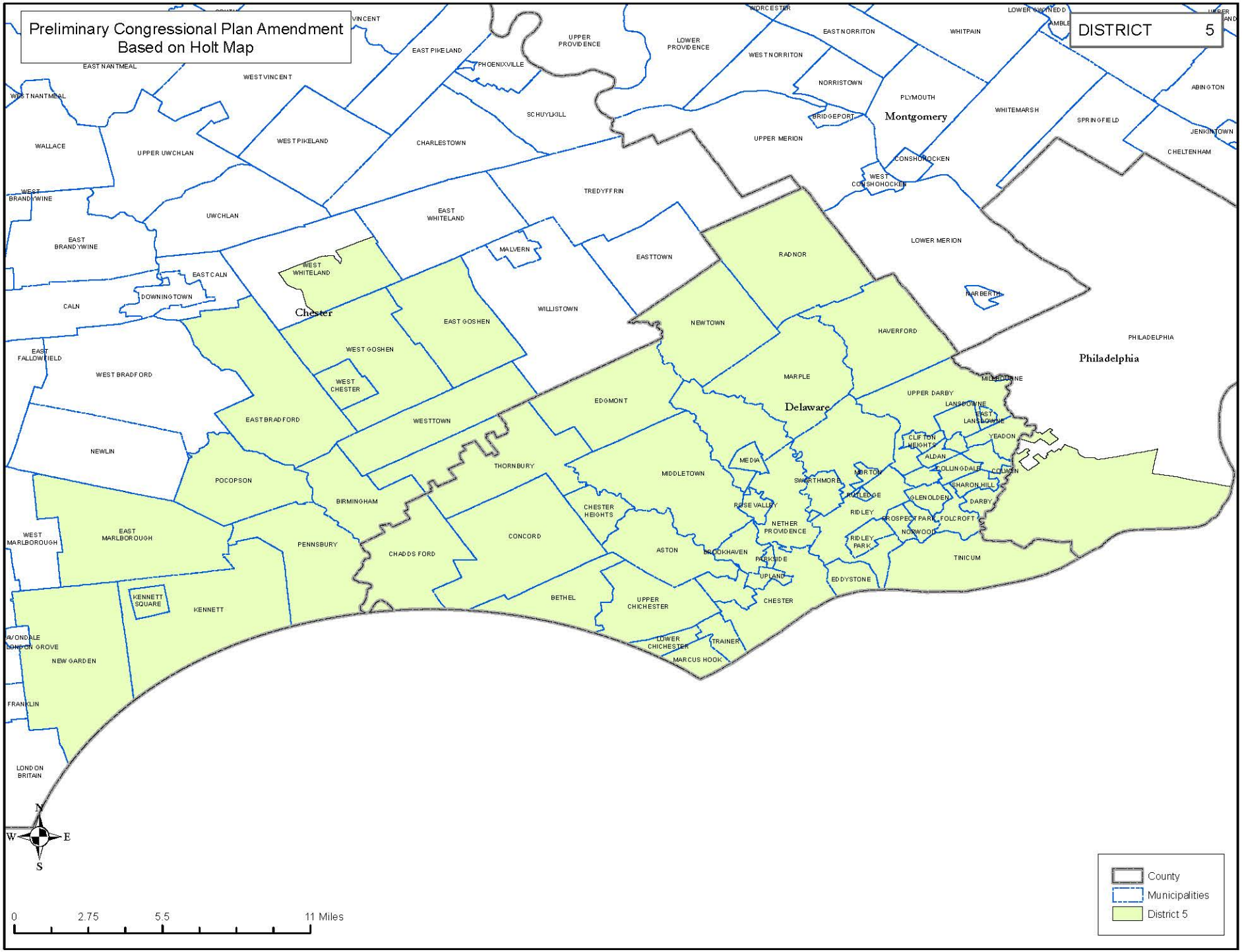
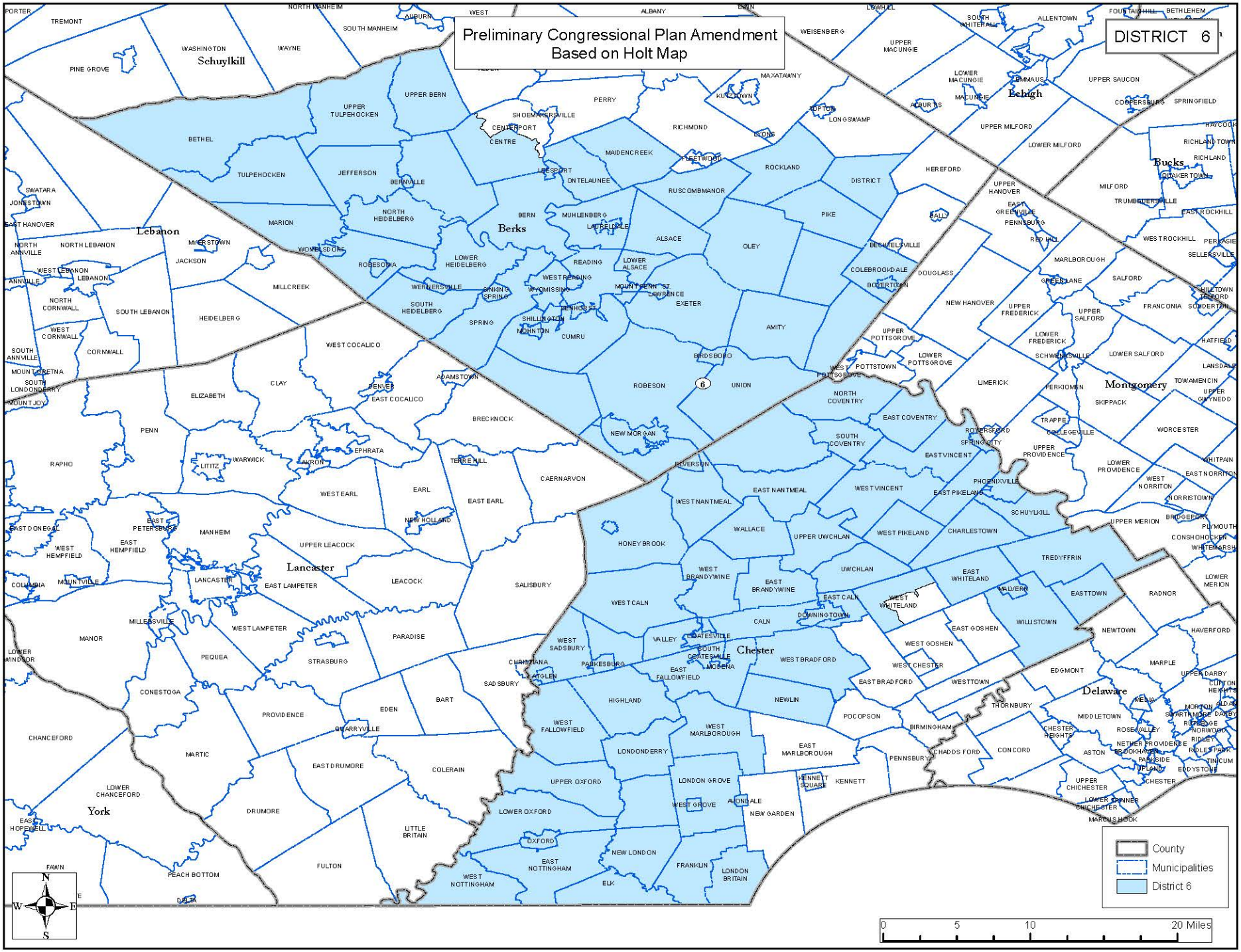
Ward 19
Ward 43
Ward 7
Ward 33
Ward 25
Ward 46
Ward 23
Ward 42
Ward 61
Ward 35
Ward 53
Ward 54
Ward 62
Ward 55
Ward 41
Ward 64
Ward 65
Ward 56
Ward 57
Ward 63
Ward 66
Ward 58
N
W
E
S
County
Municipalities
District 2
0
1.25
2.5
5 Miles

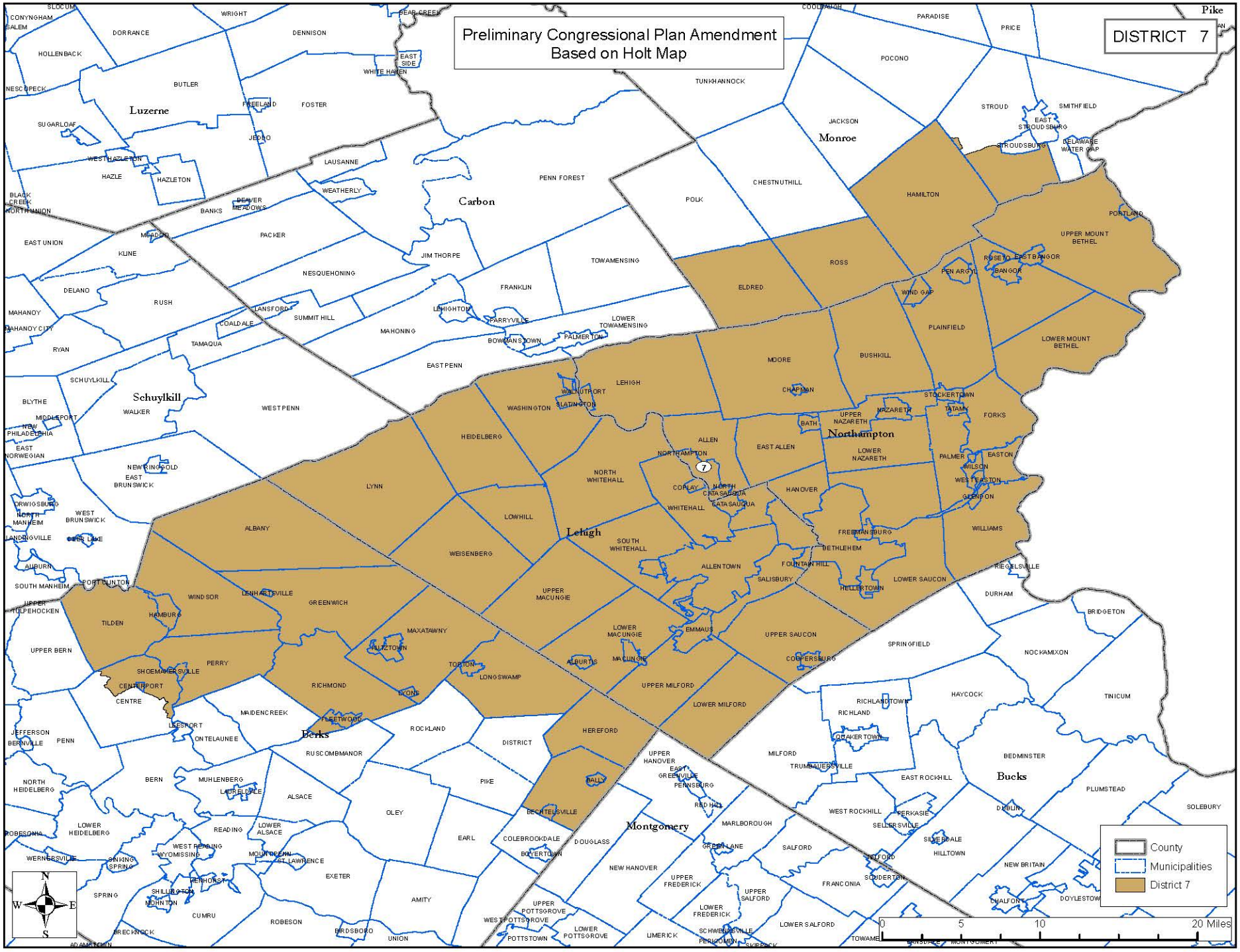
A192

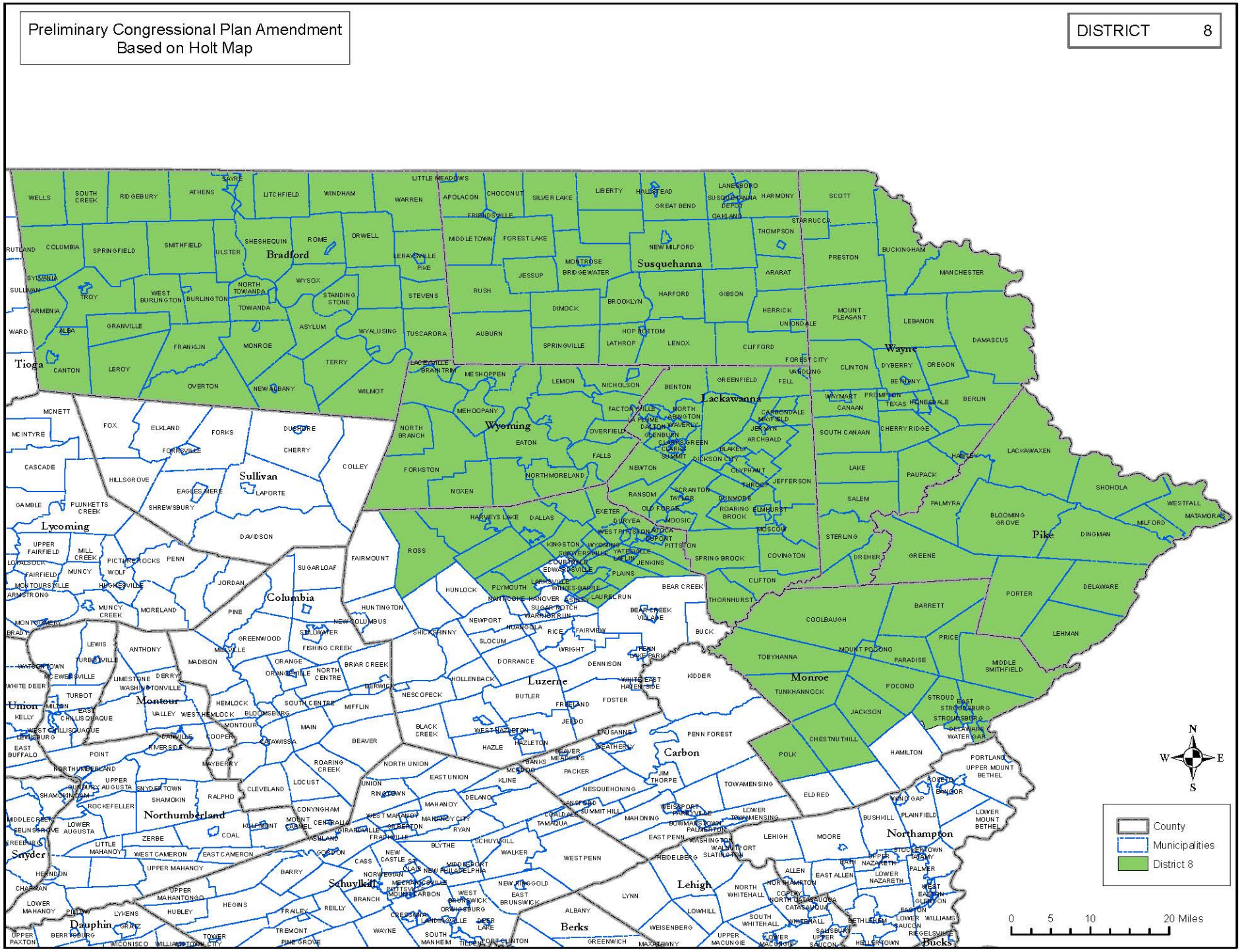

Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 3
Montgomery
Philadelphia
Delaware
LOWER MERION
WHITEMARSH
SPRINGFIELD
CHELTENHAM
JENKINTOWN
ROCKLEDGE
CONSHOHOCKEN
WEST CONSHOHOCKEN
UPPER MERION
RADNOR
HAVERFORD
NARBERTH
UPPER DARBY
MILLBOURNE
LANSDOWNE
EAST LANSDOWNE
YEADON
CLIFTON HEIGHTS
ALDAN
DARBY
COLLINGDALE
COLWYN
SHARON HILL
GLENOLDEN
NORWOOD
MORTON
RIDLEY
RUTLEDGE
PHILADELPHIA
0 1 2 4 Miles
N
W
E
S
County
Municipalities
District 3


Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 4
Lehigh
Berks
Bucks
Montgomery
Chester
Delaware
Philadelphia
Lower Milford
Upper Milford
Milford
Trumbauersville
Quakertown
Richland
Haycock
East Rockhill
Bedminster
Plumstead
Solebury
Tinicum
Dublin
Perkasie
Sellersville
West Rockhill
Hilltown
Silverdale
Telford
Souderton
Franconia
New Britain
Buckingham
Doylestown
Chalfont
Hatfield
Warrington
Wrightstown
Warwick
Northampton
Newtown
Upper Salford
Lower Salford
Marlborough
Salford
Upper Hanover
Red Hill
Pennsburg
East Greenville
Bally
Washington
Pike
Earl
Colebrookdale
Boyertown
Douglass
New Hanover
Upper Frederick
Lower Frederick
Schwenksville
Green Lane
Upper Pottsgrove
West Pottsgrove
Pottstown
Lower Pottsgrove
Limerick
Perkiomen
Skippack
Worcester
Towamencin
Lansdale
Montgomery
Upper Gwynedd
North Wales
Lower Gwynedd
Horsham
Warminster
Hatboro
Upper Southampton
Lower Southampton
Upper Moreland
Lower Moreland
Bryn Athyn
Upper Dublin
Ambler
Whitpain
East Norriton
West Norriton
Lower Providence
Upper Providence
Trappe
Collegeville
Royersford
Spring City
Phoenixville
East Pikeland
West Vincent
East Vincent
East Nantmeal
North Coventry
East Coventry
South Coventry
Norristown
Plymouth
Whitemarsh
Springfield
Abington
Jenkintown
Cheltenham
Rockledge
Bridgeport
Upper Merion
Conshohocken
West Conshohocken
Lower Merion
Narberth
Radnor
Haverford
Upper Darby
Lansdowne
East Lansdowne
Yeadon
Clifton Heights
Aldan
Darby
Millbourne
Marple
Edgmont
Middletown
Media
Nether Providence
Thornbury
Westtown
West Chester
East Goshen
West Goshen
East Bradford
West Bradford
Willistown
Malvern
East Whiteland
West Whiteland
Easttown
Tredyffrin
Charlestown
West Pikeland
Schuylkill
Upper Uwchlan
Uwchlan
East Caln
Downingtown
Newlin
Pocopson
Birmingham
Chadds Ford
Kennett Square
Philadelphia
0 3 6 12 Miles
N
W E
S
County
Municipalities
District 4


Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 5
Montgomery
Chester
Delaware
Philadelphia
Philadelphia
EAST NANTMEAL
WEST NANTMEAL
WEST VINCENT
EAST PIKELAND
PHOENIXVILLE
UPPER PROVIDENCE
LOWER PROVIDENCE
WEST NORRITON
EAST NORRITON
WHITPAIN
NORRISTOWN
PLYMOUTH
WHITEMARSH
SPRINGFIELD
ABINGTON
JENKINTOWN
CHELTENHAM
BRIDGEPORT
SCHUYLKILL
UPPER MERION
CONSHOHOCKEN
WEST CONSHOHOCKEN
WALLACE
UPPER UWCHLAN
WEST PIKELAND
CHARLESTOWN
TREDYFFRIN
WEST BRANDYWINE
UWCHLAN
EAST WHITELAND
EAST BRANDYWINE
MALVERN
EASTTOWN
RADNOR
LOWER MERION
HARBERTH
EAST CALN
DOWNINGTOWN
CALN
WEST WHITELAND
WILLISTOWN
NEWTOWN
HAVERFORD
EAST GOSHEN
WEST GOSHEN
WEST CHESTER
EAST FALLOWFIELD
WEST BRADFORD
EDGMONT
MARPLE
UPPER DARBY
MILLBOURNE
LANSDOWNE
EAST LANSDOWNE
YEADON
CLIFTON HEIGHTS
ALDAN
COLLINGDALE
COLWYN
SHARON HILL
EAST BRADFORD
WESTTOWN
NEWLIN
THORNBURY
MEDIA
MIDDLETOWN
SWARTHMORE
MORTON
RUTLEDGE
GLENOLDEN
DARBY
POCOPSON
BIRMINGHAM
CHESTER HEIGHTS
ROSE VALLEY
RIDLEY
PROSPECT PARK
FOLCROFT
NETHER PROVIDENCE
NORWOOD
RIDLEY PARK
WEST MARLBOROUGH
EAST MARLBOROUGH
PENNSBURY
CHADDS FORD
CONCORD
ASTON
BROOKHAVEN
PARKSIDE
UPLAND
EDDYSTONE
TINICUM
KENNETT SQUARE
KENNETT
BETHEL
UPPER CHICHESTER
CHESTER
AVONDALE
LONDON GROVE
NEW GARDEN
LOWER CHICHESTER
TRAINER
MARCUS HOOK
FRANKLIN
LONDON BRITAIN
N
W
E
S
0
2.75
5.5
11 Miles
County
Municipalities
District 5

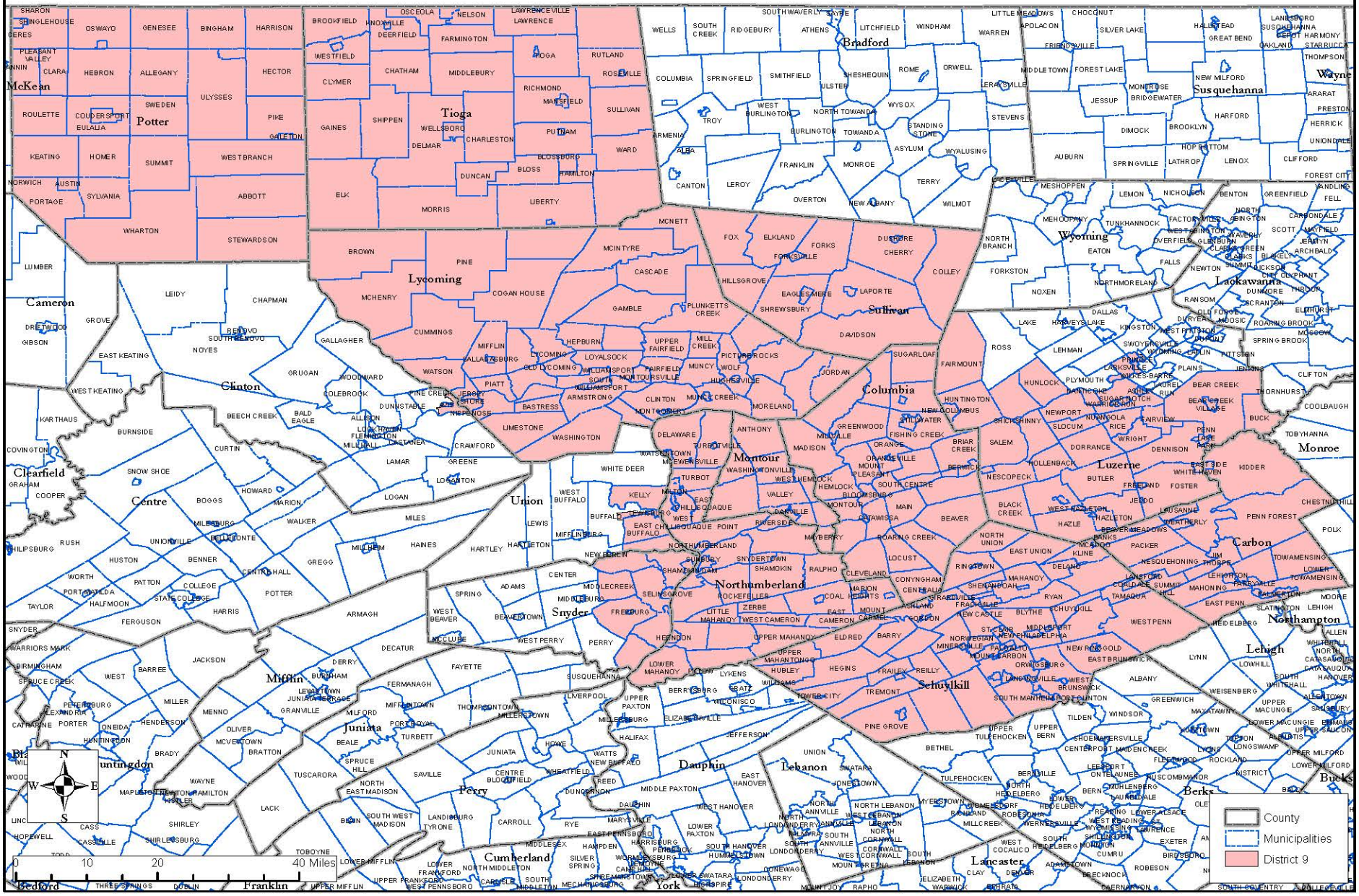

Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 6
Schuylkill
Berks
Lebanon
Lancaster
Chester
Delaware
Montgomery
Bucks
Lehigh
York
6
County
Municipalities
District 6
0 5 10 20 Miles
N
S
E
W

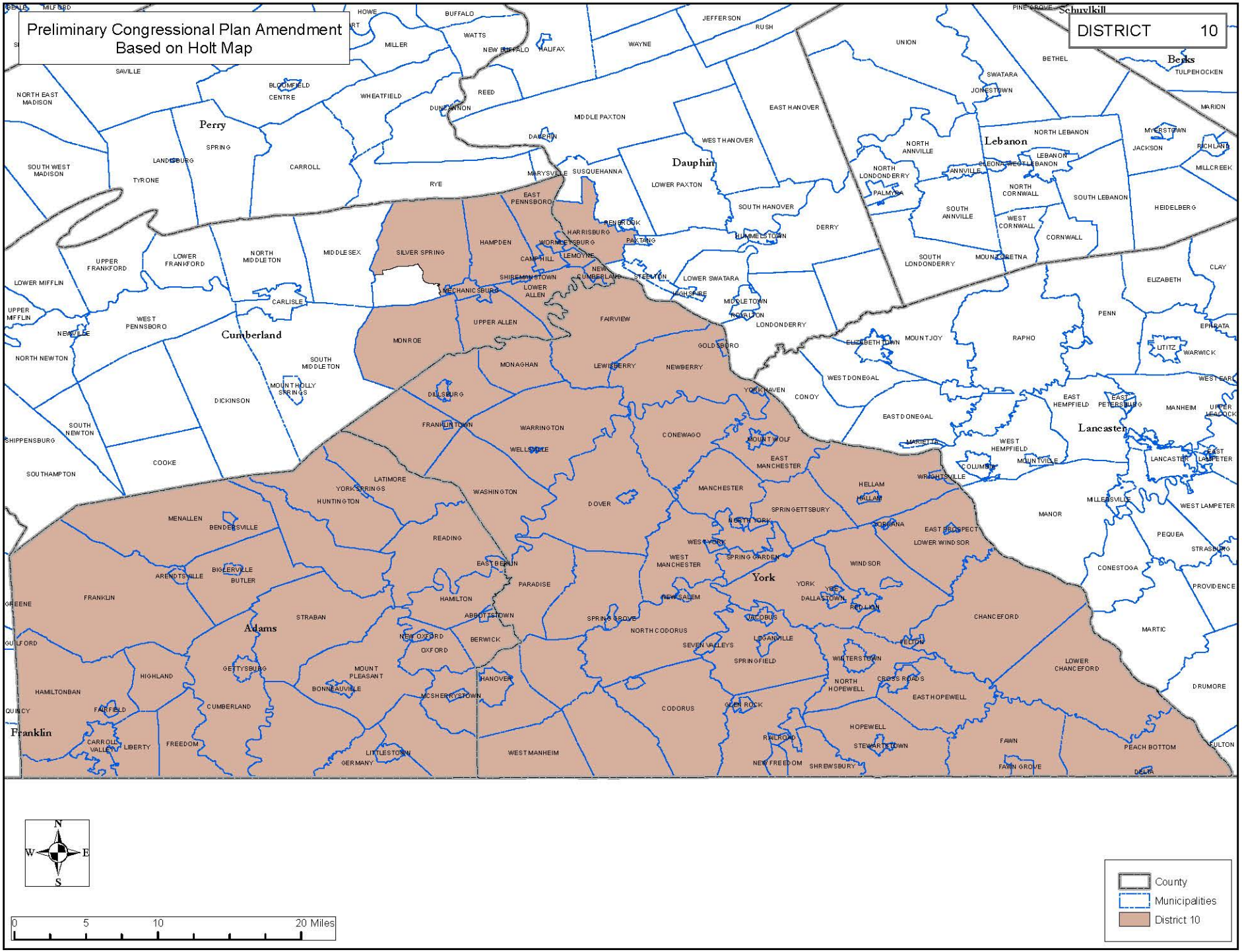

Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 7
Luzerne
Carbon
Monroe
Pike
Schuylkill
Northampton
Lehigh
Berks
Montgomery
Bucks
County
Municipalities
District 7
0 5 10 20 Miles
N
W
E
S

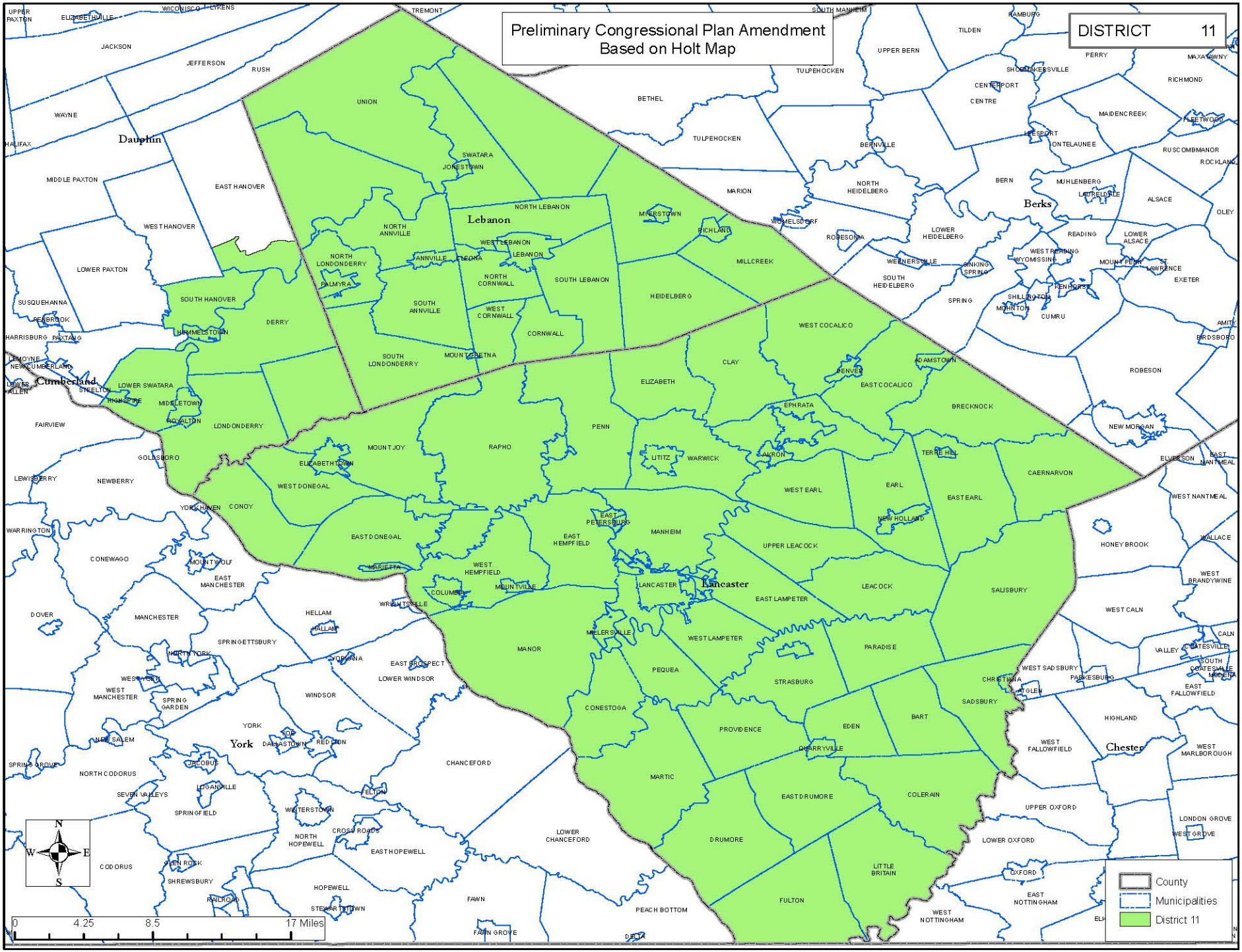

Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 8
Tioga
Bradford
Susquehanna
Wayne
Lackawanna
Wyoming
Sullivan
Lycoming
Columbia
Montour
Union
Snyder
Northumberland
Dauphin
Schuylkill
Luzerne
Carbon
Monroe
Pike
Northampton
Lehigh
Berks
Bucks
County
Municipalities
District 8
0 5 10 20 Miles
N
W
E
S

Preliminary Congressional Plan Amendment
Based on Holt Map

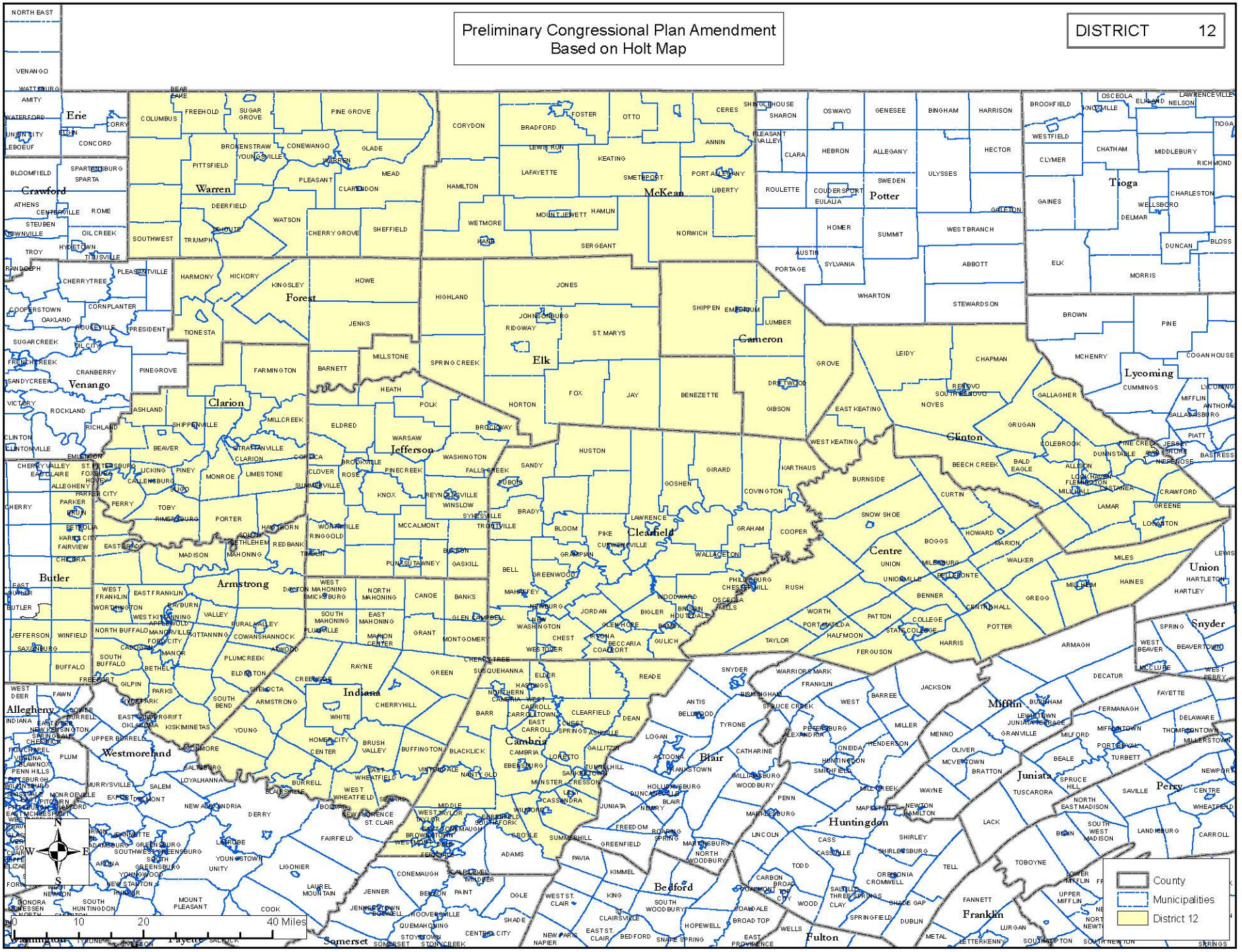
DISTRICT 9



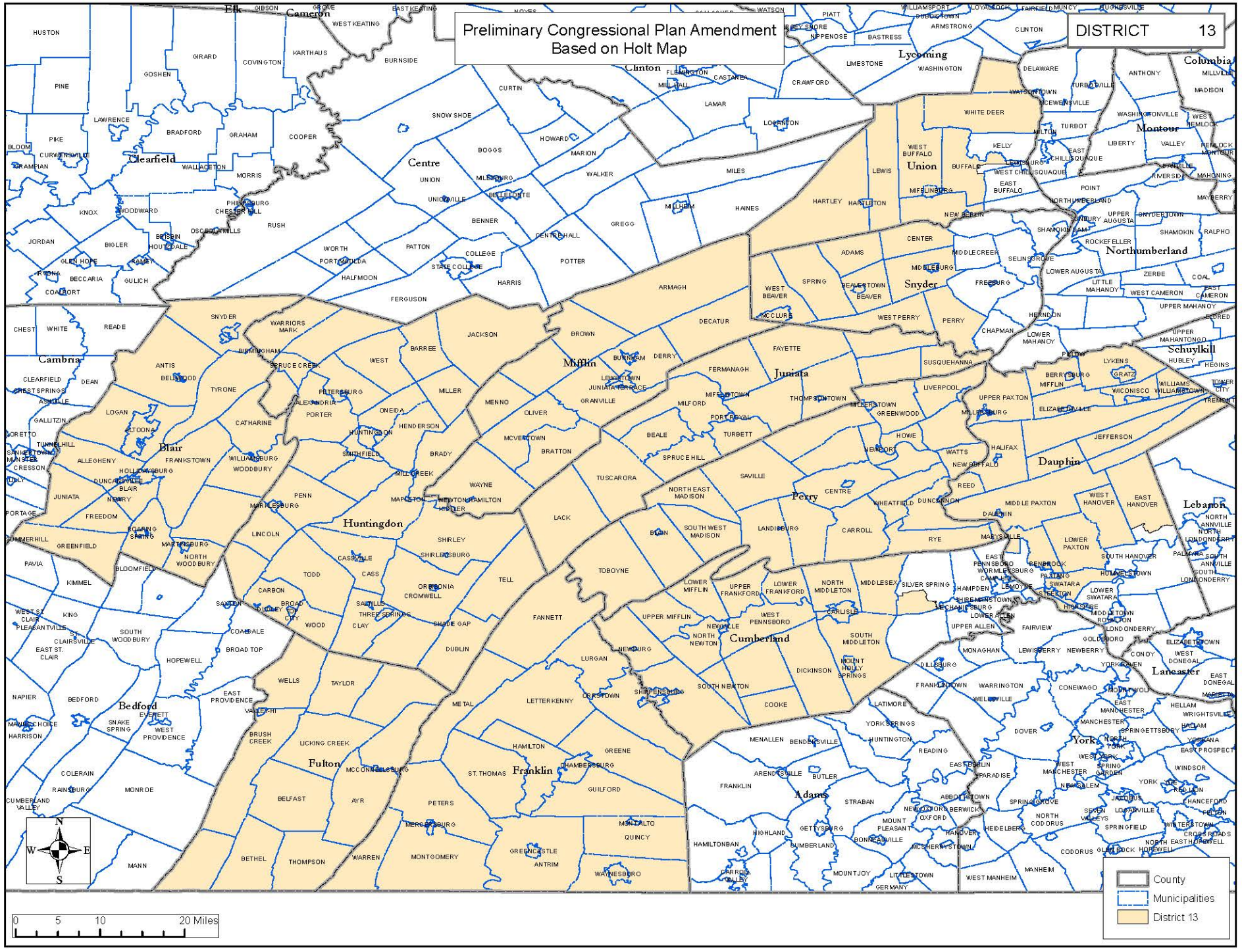

Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 10
Perry
Dauphin
Lebanon
Berks
Cumberland
Adams
York
Lancaster
Franklin
N
W
E
S
0 5 10 20 Miles
County
Municipalities
District 10

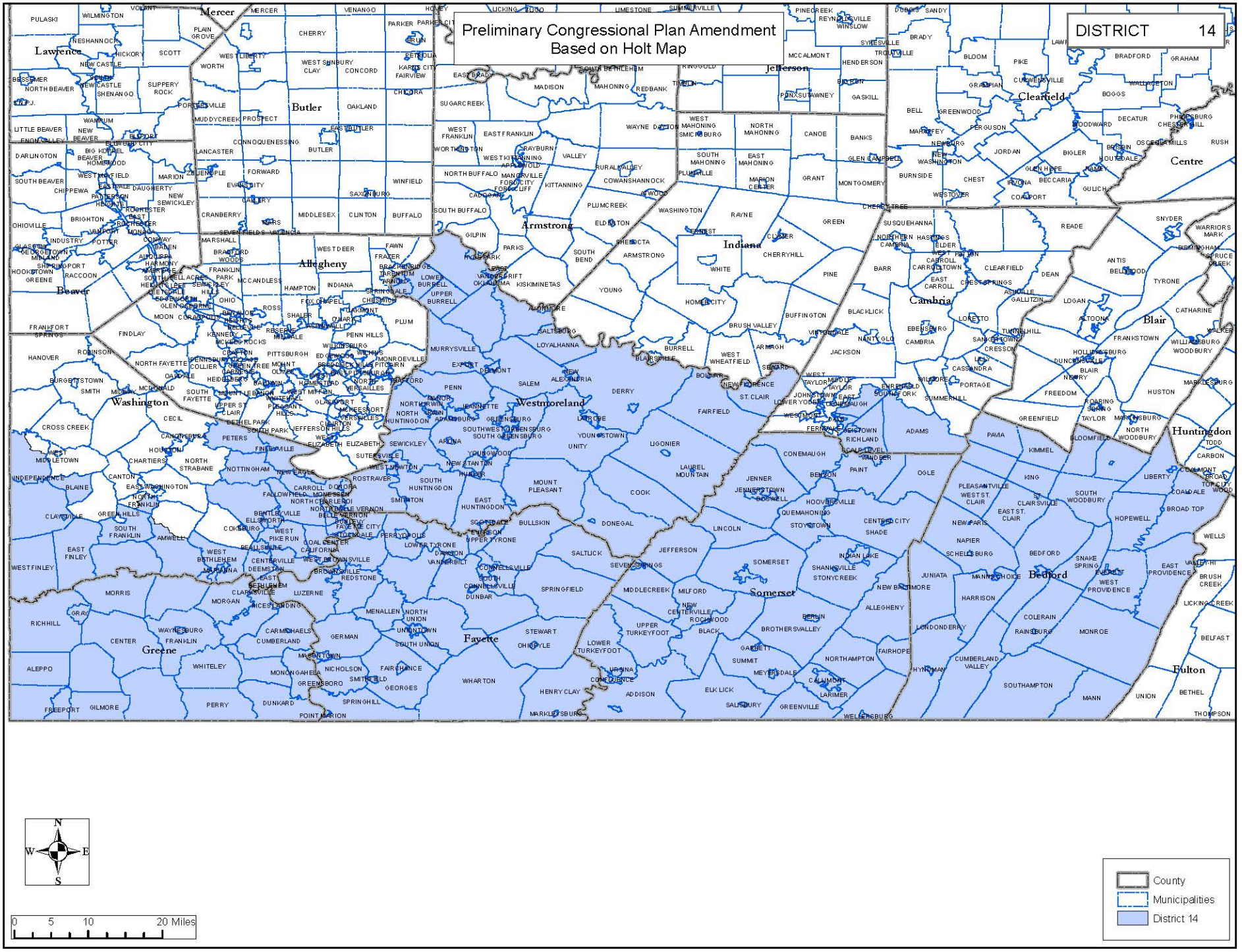

Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 11
Dauphin
Lebanon
Berks
Cumberland
Lancaster
York
Chester
0 4.25 8.5 17 Miles
N
W
E
S
County
Municipalities
District 11

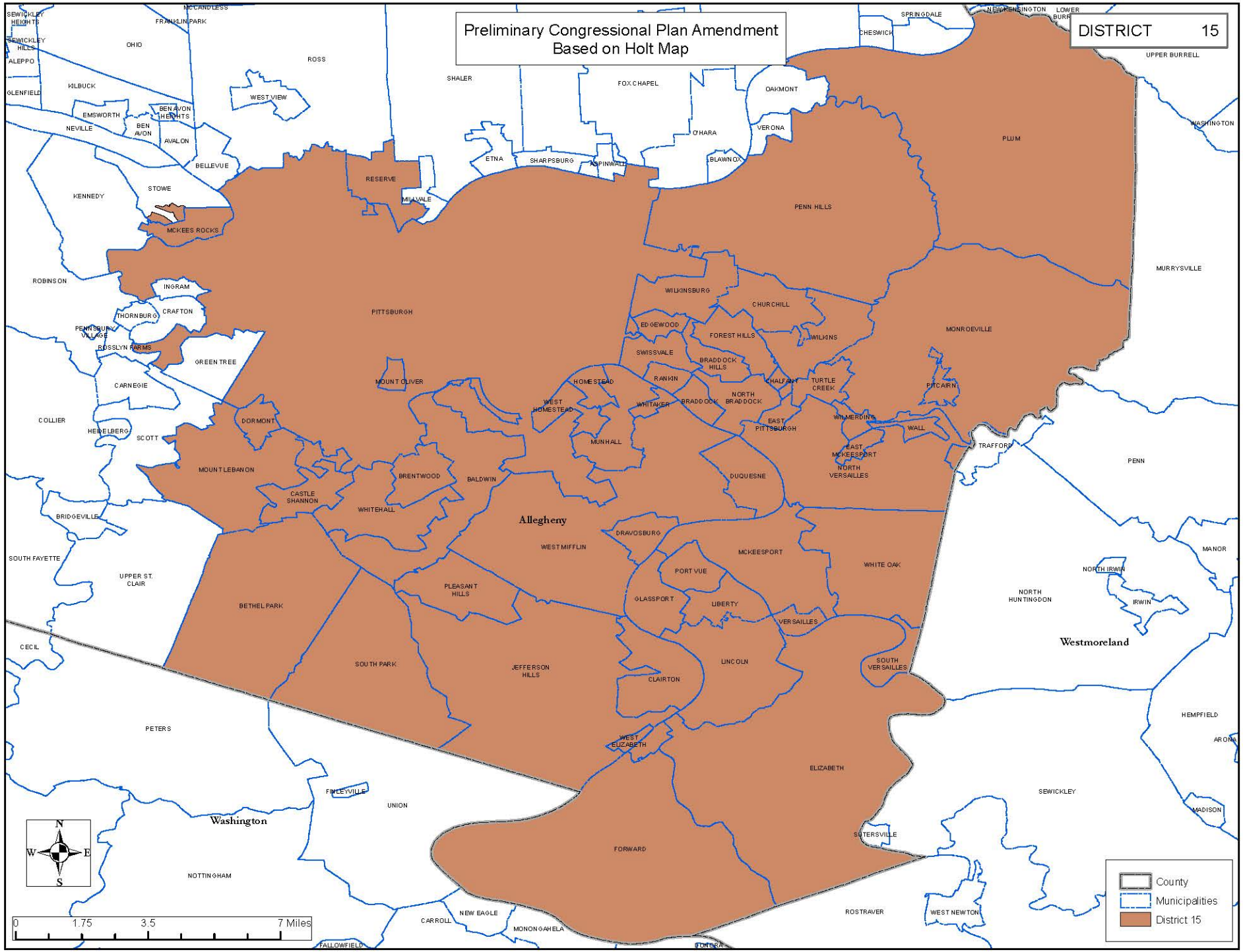
A201


Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 12
Erie
Crawford
Warren
McKean
Potter
Tioga
Forest
Elk
Cameron
Lycoming
Venango
Clarion
Jefferson
Clinton
Butler
Armstrong
Indiana
Cambria
Clearfield
Centre
Union
Snyder
Allegheny
Westmoreland
Blair
Mifflin
Juniata
Perry
Huntingdon
Bedford
Franklin
Fulton
Somerset
Washington
Fayette
Greene
0 10 20 40 Miles
County
Municipalities
District 12

A202


Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 13
Clearfield
Centre
Union
Lycoming
Clinton
Columbia
Montour
Northumberland
Snyder
Schuylkill
Cambria
Blair
Mifflin
Juniata
Dauphin
Perry
Huntingdon
Cumberland
Lebanon
Lancaster
Bedford
Fulton
Franklin
Adams
York
N
W
E
S
0 5 10 20 Miles
County
Municipalities
District 13

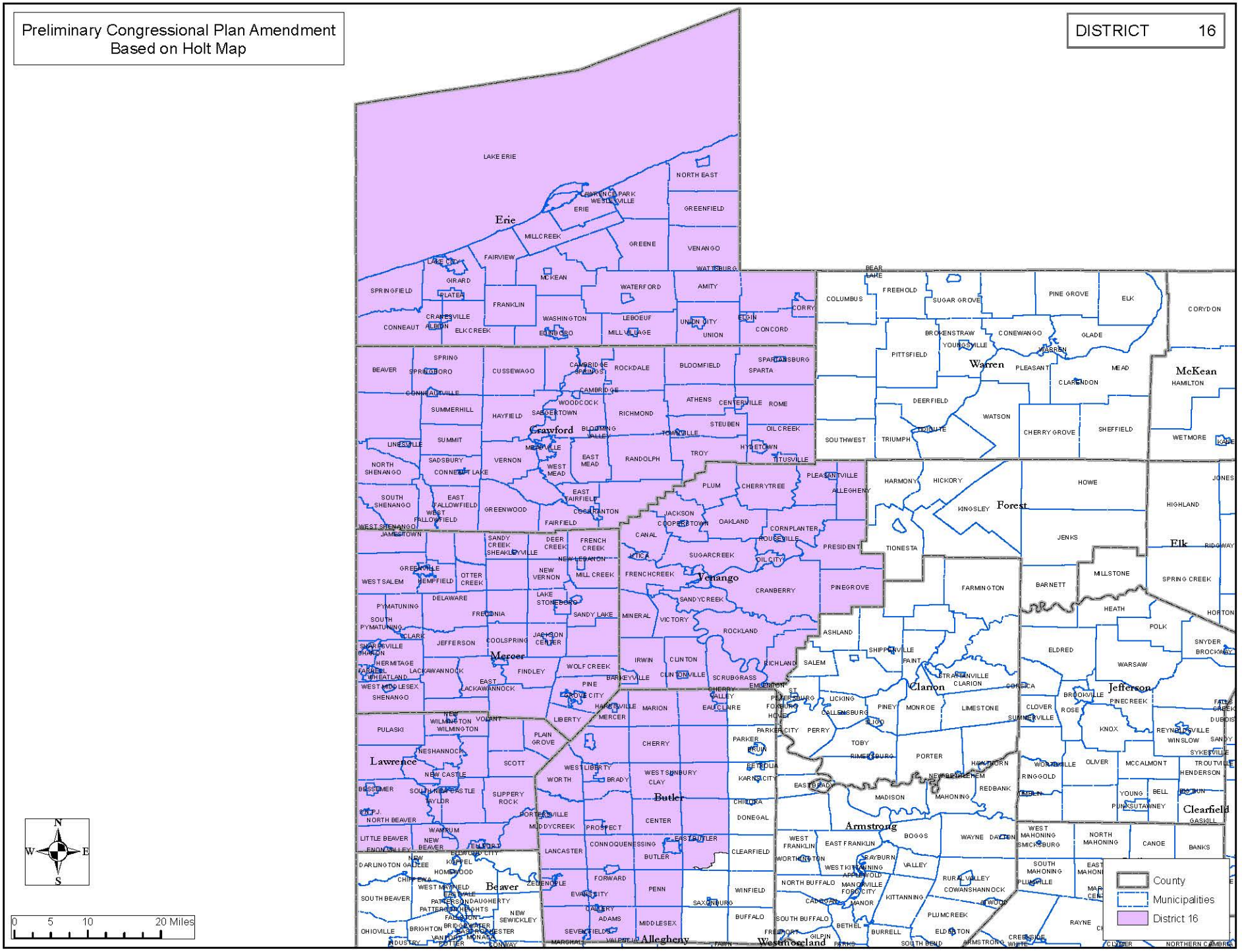

Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 14
Mercer
Lawrence
Butler
Jefferson
Clearfield
Centre
Armstrong
Indiana
Allegheny
Beaver
Cambria
Blair
Washington
Westmoreland
Huntingdon
Greene
Fayette
Somerset
Bedford
Fulton
N
W
E
S
0 5 10 20 Miles
County
Municipalities
District 14

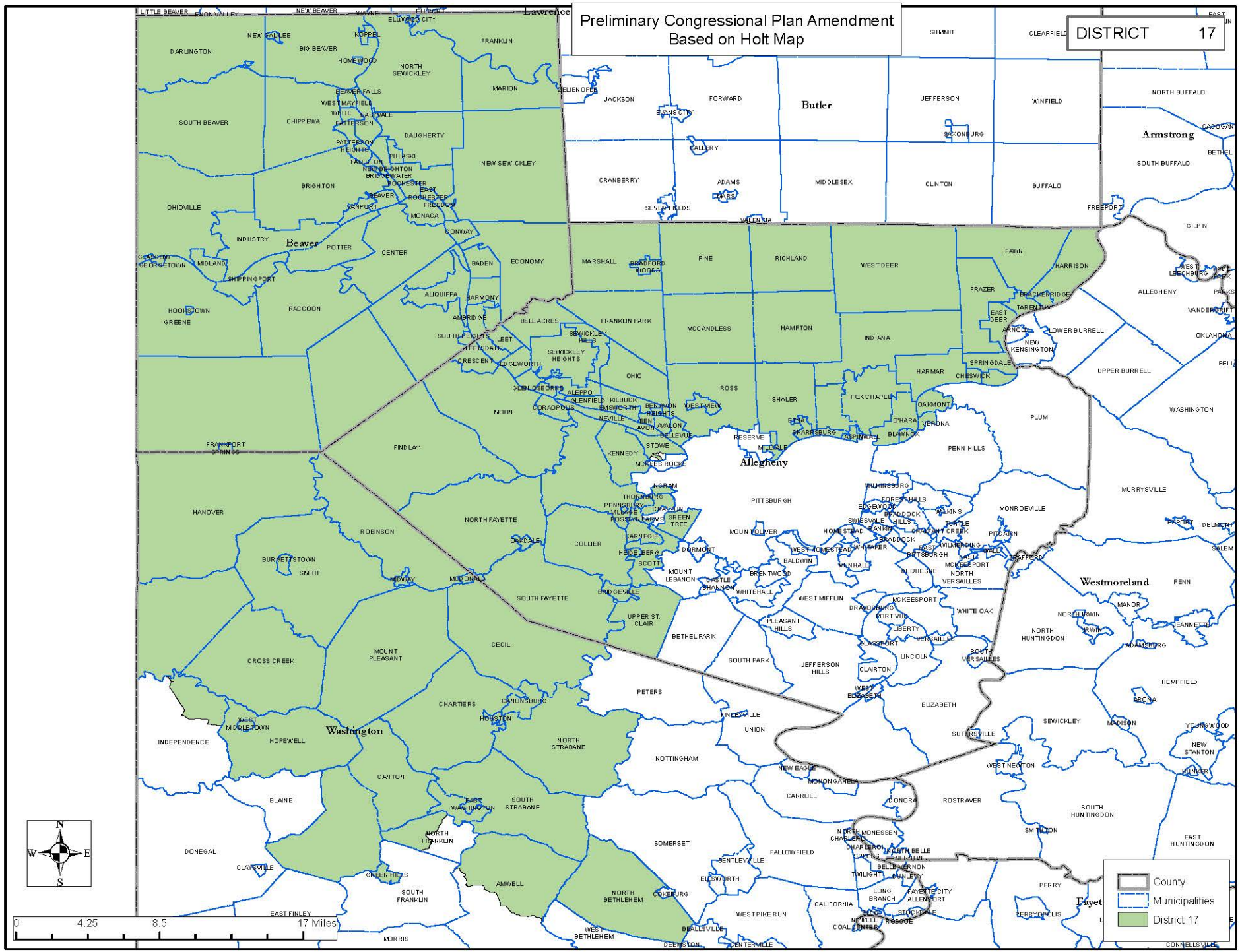

Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 15
Allegheny
Washington
Westmoreland
PITTSBURGH
MCKEES ROCKS
STOWE
KENNEDY
ROBINSON
INGRAM
CRAFTON
THORNBURG
PENNSBURY VILLAGE
ROSSLYN FARMS
GREEN TREE
CARNEGIE
COLLIER
HEIDELBERG
SCOTT
DORMONT
MOUNT LEBANON
BRIDGEVILLE
SOUTH FAYETTE
UPPER ST. CLAIR
CASTLE SHANNON
WHITEHALL
BRENTWOOD
BALDWIN
MOUNT OLIVER
CARRICK
BETHEL PARK
SOUTH PARK
PLEASANT HILLS
JEFFERSON HILLS
WEST MIFFLIN
DRAVOSBURG
CLAIRTON
PORT VUE
GLASSPORT
LIBERTY
VERSAILLES
MCKEESPORT
DUQUESNE
MUNHALL
HOMESTEAD
WEST HOMESTEAD
WHITAKER
BRADDOCK
NORTH BRADDOCK
RANKIN
SWISSVALE
EDGEWOOD
WILKINSBURG
FOREST HILLS
CHURCHILL
WILKINS
BRADDOCK HILLS
CHALFANT
TURTLE CREEK
EAST PITTSBURGH
WILMERDING
WALL
EAST MCKEESPORT
NORTH VERSAILLES
TRAFFORD
PENN
MONROEVILLE
PITCAIRN
PENN HILLS
PLUM
MURRYSVILLE
WASHINGTON
UPPER BURRELL
LOWER BURRELL
NEW KENSINGTON
SPRINGDALE
CHESWICK
OAKMONT
VERONA
O'HARA
BLAWNOX
ASPINWALL
SHARPSBURG
ETNA
FOX CHAPEL
SHALER
ROSS
WEST VIEW
RESERVE
MILLVALE
BELLEVUE
BEN AVON
BEN AVON HEIGHTS
AVALON
EMSWORTH
NEVILLE
KILBUCK
GLENFIELD
ALEPPO
SEWICKLEY HEIGHTS
SEWICKLEY HILLS
OHIO
FRANKLIN PARK
MCCANDLESS
WHITE OAK
NORTH IRWIN
IRWIN
NORTH HUNTINGDON
MANOR
SOUTH VERSAILLES
LINCOLN
ELIZABETH
WEST ELIZABETH
FORWARD
SUTERSVILLE
SEWICKLEY
HEMPFIELD
MADISON
ARONA
ROSTRAVER
WEST NEWTON
MONONGAHELA
NEW EAGLE
CARROLL
FALLOWFIELD
NOTTINGHAM
PETERS
FINLEYVILLE
UNION
CECIL
N
W
E
S
0
1.75
3.5
7 Miles
County
Municipalities
District 15

A205

Preliminary Congressional Plan Amendment
Based on Holt Map

DISTRICT 16




Preliminary Congressional Plan Amendment
Based on Holt Map
DISTRICT 17
Lawrence
Butler
Armstrong
Beaver
Allegheny
Washington
Westmoreland
Fayette
County
Municipalities
District 17
0 4.25 8.5 17 Miles
N
W
E
S

A207